FORM PTO-1390 (Modified) (REV 11-2000) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER: **217638US0PCT**

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR): **10/030946**

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/EP00/06056	**29 June 2000**	**17 July 1999**

TITLE OF INVENTION

PROCESS FOR PREPARING AMINES BY HOMOGENEOUSLY CATALYZED REDUCTIVE AMINATION OF CARBONYL COMPOUNDS

APPLICANT(S) FOR DO/EO/US

RIERMEIER Thomas et al.

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include itens (5), (6), (9) and (24) indicated below.
4. ☒ The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371 (c) (2))
   a. ☐ is attached hereto (required only if not communicated by the International Bureau).
   b. ☒ has been communicated by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. ☒ is attached hereto.
   b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3))
   a. ☐ are attached hereto (required only if not communicated by the International Bureau).
   b. ☐ have been communicated by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☒ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)).
10. ☒ An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).
11. ☐ A copy of the International Preliminary Examination Report (PCT/IPEA/409).
12. ☒ A copy of the International Search Report (PCT/ISA/210).

Items 13 to 20 below concern document(s) or information included:

13. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
14. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
15. ☒ A **FIRST** preliminary amendment.
16. ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
17. ☐ A substitute specification.
18. ☐ A change of power of attorney and/or address letter.
19. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
20. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).
21. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
22. ☐ Certificate of Mailing by Express Mail
23. ☒ Other items or information:

Notice of Priority/Form PTO-1449
Amended Sheets (Page 27)
PCT/IB/308

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NUMBER
10/030946	PCT/EP00/06056	217638US0PCT

24. The following fees are submitted:.	CALCULATIONS PTO USE ONLY	
BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :		
☐ Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO **$1040.00**		
☒ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO **$890.00**		
☐ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO **$740.00**		
☐ International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) **$710.00**		
☐ International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) **$100.00**		
ENTER APPROPRIATE BASIC FEE AMOUNT =	**$890.00**	
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☒ 30 months from the earliest claimed priority date (37 CFR 1.492 (e)).	**$130.00**	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	21 - 20 =	1	x $18.00	**$18.00**	
Independent claims	1 - 3 =	0	x $84.00	**$0.00**	
Multiple Dependent Claims **(check if applicable)**.			☐	**$0.00**	

TOTAL OF ABOVE CALCULATIONS =	**$1,038.00**	
☐ Applicant claims small entity status. See 37 CFR 1.27). The fees indicated above are reduced by 1/2.	**$0.00**	
SUBTOTAL =	**$1,038.00**	
Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (f)). +	**$0.00**	
TOTAL NATIONAL FEE =	**$1,038.00**	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) **(check if applicable).** ☐	**$0.00**	
TOTAL FEES ENCLOSED =	**$1,038.00**	
	Amount to be: refunded	$
	charged	$

a. ☒ A check in the amount of **$1,038.00** to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. _____ in the amount of _____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. **15-0030** A duplicate copy of this sheet is enclosed.

d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

Surinder Sachar
Registration No. 34,423

22850

Surinder Sachar
SIGNATURE

Norman F. Oblon
NAME

24,618
REGISTRATION NUMBER

Jan 15 2002
DATE

217638US-0PCT

IN THE UNITED STATES PATENT & TRADEMARK OFFICE

IN RE APPLICATION OF :

THOMAS REIRMEIER ET AL : ATTN: APPLICATION DIVISION

SERIAL NO: NEW U.S. PCT APPLN :
(Based on PCT/EP00/06056)

FILED: HEREWITH :

FOR: PROCESS FOR PREPARING :
AMINES BY HOMOGENEOUSLY
CATALYZED REDUCTIVE
AMINATION OF CARBONYL
COMPOUNDS

PRELIMINARY AMENDMENT

ASSISTANT COMMISSIONER FOR PATENTS
WASHINGTON, D.C. 20231

SIR:

Prior to examination on the merits, please amend the above-identified application as follows.

IN THE CLAIMS

Please amend the claims as shown on the marked-up copy following this amendment to read as follows.

3. (Amended) The process as claimed in claim 1, wherein R^6 to R^9 are selected independently from the group consisting of $(C_3$-$C_8)$-alkyl, $(C_6$-$C_{10})$-aryl, O-$(C_5$-$C_8)$-alkyl, O-$(C_6$-$C_{10})$-aryl or an aliphatic or aromatic $(C_3$-$C_9)$-heterocycle containing from 1 to 4 nitrogen atoms.

4. (Amended) The process as claimed in claim 1, wherein R^6 and R^7 and/or R^8 and R^9 may be linked by a covalent bond so as to form a cyclic compound having from four to eight atoms.

5. (Amended) The process as claimed in claim 1, wherein ligands in which Y^1 and Y^2 are each a direct phosphorus-carbon bond are used.

6. (Amended) The process as claimed in claim 1, wherein Z comprises from one to four carbon atoms, in particular two carbon atoms.

7. (Amended) The process as claimed in claim 1, wherein Z is a C_1-C_6-alkyl or C_2-C_6-alkenyl group or is part of a C_3-C_8-cycloalkyl, C_5-C_8-cycloalkenyl, C_2-C_9-heterocycloalkyl, C_1-C_9-heterocycloalkenyl, C_6-C_{14}-aryl, phenyl, naphthyl, fluorenyl or C_2-C_{13}-heteroaryl group, where the number of heteroatoms from the group consisting of N, O, S can be 1-4 and all these groups may be monosubstituted or polysubstituted.

8. (Amended) The process as claimed in claim 1, wherein ligands in which a three- to nine-membered ring system can be formed by Z, X^1, X^2, P^1 and P^2 together with a coordinated metal are used.

10. (Amended) The process as claimed in claim 1, wherein the starting materials of the formulae (I) and/or (II) used are ones whose substituents R^1 to R^4 are each, independently of one another, hydrogen, (C_1-C_{12})-alkyl, (C_2-C_{12})-alkenyl, (C_2-C_{12})-alkynyl, (C_6-C_{10})-aryl, CF_3, CN, COOH, COOM, where M is a cation selected from the group consisting of Li^+, Na^+, K^+, Mg^{2+}, Ca^{2+}, NH_4^+, $N(C_1\text{-}C_{10}\text{-alkyl})_4^+$, $N(C_1\text{-}C_{10}\text{-alkyl}/C_6\text{-}C_{10}\text{-aryl})_4^+$, COO-alkyl-($C_1$-$C_8$), $CONH_2$, CONHalkyl-(C_1-C_8), $CONalkyl_2$-(C_1-C_8), CO-alkyl-(C_1-C_8), CO-phenyl, COO-phenyl, COO-aryl-(C_6-C_{10}), CO-aryl-(C_6-C_{10}), PO(aryl-C_6-C_{10})$_2$, $POalkyl_2$-(C_1-C_4), PO_3H_2, PO(alkyl-(C_1-C_4))(Oalkyl-(C_1-C_4)), PO(O-alkyl-(C_1-C_6))$_2$ or $Si(alkyl)_3$-(C_1-C_8) and/or R^3 and R^4 are selected independently from the group consisting of O-alkyl-(C_1-

C_8), OCO-alkyl-(C_1-C_8), O-aryl(C_6-C_{10}), OH, NH_2, NH-alkyl-(C_1-C_8), N-alkyl$_2$-(C_1-C_8), NHCO-alkyl-(C_1-C_4), NHCOO-alkyl-(C_1-C_4), NHaryl-(C_6-C_{10}), where alkyl is an unbranched or branched aliphatic or cyclic or heterocyclic radical containing from one to four heteroatoms selected from the group consisting of N, O, alkenyl is an olefinic hydrocarbon, alkynyl is an acetylenic hydrocarbon and aryl is an aromatic radical which may also be an aromatic containing 1-4 heteroatoms from the group consisting of N, O and S,

and alkyl, alkenyl and alkynyl and also aryl may bear substituents selected independently from among hydrogen, O-alkyl-(C_1-C_8), OCO-alkyl-(C_1-C_8), O-phenyl, phenyl, aryl-C_6-C_{10}, fluorine, chlorine, bromine, iodine, OH, NO_2, Si-alkyl$_3$-(C_1-C_8), CF_3, CN, COOH, COOM where M is a monovalent cation selected from the group consisting of Na, K, Rb, Cs, NH_4, N(C_1-C_{10}-alkyl)$_4$, N(C_1-C_{10}-alkyl/C_6-C_{10}-aryl)$_4$, and SO_3H, N-alkyl$_2$-(C_1-C_8), SO_2-alkyl-(C_1-C_6), SO-alkyl-(C_1-C_6), NHCO-alkyl-(C_1-C_4), COO-alkyl-(C_1-C_8), $CONH_2$, CO-alkyl-(C_1-C_8), CO-phenyl, COO-phenyl, COO-aryl-(C_6-C_{10}), CO-aryl-(C_6-C_{10}), PO-phenyl$_2$, POalkyl$_2$-(C_1-C_4), PO_3H_2, POalkyl-(C_1-C_4)(O-alkyl-(C_1-C_6)), PO(O-alkyl-(C_1-C_6))$_2$, Si(alkyl)$_3$(C_1-C_8), where alkyl and aryl are as defined above.

11. (Amended) The process as claimed in claim 1, wherein the starting materials of the formulae (I) and/or (II) used are ones in which R^1 and R^2 and/or R^3 and R^4 are linked by covalent bonds so as to form a three- to nine-membered ring.

12. (Amended) The process as claimed in claim 1, wherein metal complexes having central atoms selected from the group consisting of Rh, Ru, Ir, Pd, Pt, Ni, in particular ones containing rhodium as central atom, are used as homogeneous metal atom-ligand complex.

13. (Amended) The process as claimed in claim 1, wherein alkyl is an unbranched or branched aliphatic or cyclic hydrocarbon and aryl is an aromatic radical.

15. (Amended) The process as claimed in claim 1 which is carried out at a temperature of -40-100°C.

16. (Amended) The process as claimed in claim 1 in which further additives are used.

18. (Amended) The process as claimed in claim 1 carried out using phosphinite-rhodium catalysts without the addition of additives.

19. (Amended) The process as claimed in claim 1, wherein solvents used are alcohols, water, halogenated hydrocarbons, ethers, aromatic hydrocarbons and mixtures thereof.

20. (Amended) The process as claimed in claim 1, wherein the initial hydrogen pressure is from 0.1 to 300 bar.

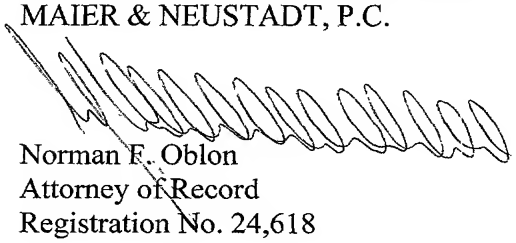
21. (Amended) The process as claimed in claim 1, wherein the catalyst system is used in an amount of from 0.001 to 5 mol%, based on the carbonyl component of the formula (I).

REMARKS

Claims 1-21 are active in the present application. Claims 3-8 and 10-13 and 15-21 have been amended to remove multiple dependencies. No new matter is added. An action on the merits and allowance of claims is solicited.

Respectfully submitted,

OBLON, SPIVAK, McCLELLAND,
MAIER & NEUSTADT, P.C.



Norman F. Oblon
Attorney of Record
Registration No. 24,618

Stefan U. Koschmieder, Ph.D.
Registration No. 50,238

22850
(703) 413-3000
Fax #: (703)413-2220
NFO:SUK\la
I:\atty\SUKOS\217638us-pr.wpd

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Serial No:

Amendment Filed on:
1-15-2002

IN THE CLAIMS

Please amend the claims as follows.

--3. (Amended) The process as claimed in [either of the preceding claims] claim 1, wherein R^6 to R^9 are selected independently from the group consisting of $(C_3$-$C_8)$-alkyl, $(C_6$-$C_{10})$-aryl, O-$(C_5$-$C_8)$-alkyl, O-$(C_6$-$C_{10})$-aryl or an aliphatic or aromatic $(C_3$-$C_9)$-heterocycle containing from 1 to 4 nitrogen atoms.

4. (Amended) The process as claimed in [any of the preceding claims] claim 1, wherein R^6 and R^7 and/or R^8 and R^9 may be linked by a covalent bond so as to form a cyclic compound having from four to eight atoms.

5. (Amended) The process as claimed in claim 1 [or 2], wherein ligands in which Y^1 and Y^2 are each a direct phosphorus-carbon bond are used.

6. (Amended) The process as claimed in [any of the preceding claims] claim 1, wherein Z comprises from one to four carbon atoms, in particular two carbon atoms.

7. (Amended) The process as claimed in [any of the preceding claims] claim 1, wherein Z is a C_1-C_6-alkyl or C_2-C_6-alkenyl group or is part of a C_3-C_8-cycloalkyl, C_5-C_8-cycloalkenyl, C_2-C_9-heterocycloalkyl, C_1-C_9-heterocycloalkenyl, C_6-C_{14}-aryl, phenyl, naphthyl, fluorenyl or C_2-C_{13}-heteroaryl group, where the number of heteroatoms from the

group consisting of N, O, S can be 1-4 and all these groups may be monosubstituted or polysubstituted [as described in claim 1].

8. (Amended) The process as claimed in [any of the preceding claims] claim 1, wherein ligands in which a three- to nine-membered ring system can be formed by Z, X^1, X^2, P^1 and P^2 together with a coordinated metal are used.

10. (Amended) The process as claimed in [any of the preceding claims] claim 1, wherein the starting materials of the formulae (I) and/or (II) used are ones whose substituents R^1 to R^4 are each, independently of one another, hydrogen, (C_1-C_{12})-alkyl, (C_2-C_{12})-alkenyl, (C_2-C_{12})-alkynyl, (C_6-C_{10})-aryl, CF_3, CN, COOH, COOM, where M is a cation selected from the group consisting of Li^+, Na^+, K^+, Mg^{2+}, Ca^{2+}, NH_4^+, $N(C_1-C_{10}\text{-alkyl})_4^+$, $N(C_1-C_{10}\text{-alkyl}/C_6-C_{10}\text{-aryl})_4^+$, COO-alkyl-$(C_1-C_8)$, $CONH_2$, CONHalkyl-(C_1-C_8), CONalkyl$_2$-(C_1-C_8), CO-alkyl-(C_1-C_8), CO-phenyl, COO-phenyl, COO-aryl-(C_6-C_{10}), CO-aryl-(C_6-C_{10}), PO(aryl-$C_6-C_{10})_2$, POalkyl$_2$-(C_1-C_4), PO_3H_2, PO(alkyl-(C_1-C_4))(Oalkyl-(C_1-C_4)), PO(O-alkyl-(C_1-C_6))$_2$ or Si(alkyl)$_3$-(C_1-C_8) and/or R^3 and R^4 are selected independently from the group consisting of O-alkyl-(C_1-C_8), OCO-alkyl-(C_1-C_8), O-aryl(C_6-C_{10}), OH, NH_2, NH-alkyl-(C_1-C_8), N-alkyl$_2$-(C_1-C_8), NHCO-alkyl-(C_1-C_4), NHCOO-alkyl-(C_1-C_4), NHaryl-(C_6-C_{10}), where alkyl is an unbranched or branched aliphatic or cyclic or heterocyclic radical containing from one to four heteroatoms selected from the group consisting of N, O, alkenyl is an olefinic hydrocarbon, alkynyl is an acetylenic hydrocarbon and aryl is an aromatic radical which may also be an aromatic containing 1-4 heteroatoms from the group consisting of N, O and S,

and alkyl, alkenyl and alkynyl and also aryl may bear substituents selected independently from among hydrogen, O-alkyl-(C_1-C_8), OCO-alkyl-(C_1-C_8), O-phenyl, phenyl, aryl-C_6-C_{10}, fluorine, chlorine, bromine, iodine, OH, NO_2, Si-alkyl$_3$-(C_1-C_8), CF_3, CN, COOH, COOM where M is a monovalent cation selected from the group consisting of Na, K,

Rb, Cs, NH_4, $N(C_1\text{-}C_{10}\text{-alkyl})_4$, $N(C_1\text{-}C_{10}\text{-alkyl}/C_6\text{-}C_{10}\text{-aryl})_4$, and SO_3H, N-alkyl$_2$-(C_1-C_8), SO_2-alkyl-(C_1-C_6), SO-alkyl-(C_1-C_6), NHCO-alkyl-(C_1-C_4), COO-alkyl-(C_1-C_8), $CONH_2$, CO-alkyl-(C_1-C_8), CO-phenyl, COO-phenyl, COO-aryl-(C_6-C_{10}), CO-aryl-(C_6-C_{10}), PO-phenyl$_2$, POalkyl$_2$-(C_1-C_4), PO_3H_2, POalkyl-(C_1-C_4)(O-alkyl-(C_1-C_6)), PO(O-alkyl-(C_1-C_6))$_2$, Si(alkyl)$_3$(C_1-C_8), where alkyl and aryl are as defined above.

11. (Amended) The process as claimed in [any of the preceding claims] claim 1, wherein the starting materials of the formulae (I) and/or (II) used are ones in which R^1 and R^2 and/or R^3 and R^4 are linked by covalent bonds so as to form a three- to nine-membered ring.

12. (Amended) The process as claimed in [any of the preceding claims] claim 1, wherein metal complexes having central atoms selected from the group consisting of Rh, Ru, Ir, Pd, Pt, Ni, in particular ones containing rhodium as central atom, are used as homogeneous metal atom-ligand complex.

13. (Amended) The process as claimed in [any of the preceding claims] claim 1, wherein alkyl is an unbranched or branched aliphatic or cyclic hydrocarbon and aryl is an aromatic radical.

15. (Amended) The process as claimed in [any of the preceding claims] claim 1 which is carried out at a temperature of -40-100°C.

16. (Amended) The process as claimed in [any of the preceding claims] claim 1 in which further additives are used.

18. (Amended) The process as claimed in [any of claims 1 to 15] claim 1 carried out using phosphinite-rhodium catalysts without the addition of additives.

19. (Amended) The process as claimed in [any of the preceding claims] claim 1, wherein solvents used are alcohols, water, halogenated hydrocarbons, ethers, aromatic hydrocarbons and mixtures thereof.

20. (Amended) The process as claimed in [any of the preceding claims] claim 1, wherein the initial hydrogen pressure is from 0.1 to 300 bar.

21. (Amended) The process as claimed in [any of the preceding claims] claim 1, wherein the catalyst system is used in an amount of from 0.001 to 5 mol%, based on the carbonyl component of the formula (I).--

Process for preparing amines by homogeneously catalyzed reductive amination of carbonyl compounds

Description

The invention relates to the preparation of amines by reaction of aldehydes or ketones with ammonia or primary or secondary amines in the presence of hydrogen and in the presence of homogeneous metal catalysts under mild conditions. Metal catalysts which can be used are complexes of late transition metals with phosphorus-containing ligands. The process of the invention also makes possible the synthesis of enantiomerically pure or enantiomerically enriched amines by means of an enantioselective or diastereoselective reaction.

Racemic and enantiomerically pure amines play a dominant role in numerous complex natural substances, for example alkaloids, vitamins or amino acids, whose chemical, pharmaceutical and industrial importance is undisputed. As chemical intermediates amines are employed in, for example, the synthesis of pharmaceuticals, agrochemicals, food additives, dyes or cosmetics. In the field of active compounds, amino acids and amino alcohols play a predominant role.

Heterogeneously catalyzed amination of ketones and aldehydes plays an important role in the synthesis of unfunctionalized and functionalized amines (Catalytic Hydrogenation over Platinum Metals, Academic Press, New York, 1967, p. 291 ff; Catalytic Hydrogenation in Organic Synthesis, Academic Press, New York, 1979, 165 ff). Heterogeneous catalysts which have been used are, for example, $CuCr_2O_4 \cdot CuO$ (Kurc et al., Chem. Prum. 1987, 37, 26), Re or Cu (DE-A-19631521), Raney nickel (EP-A-0011401), Ru supported on MgO/Al_2O_3 (DE-A-4010252), Ru supported on γ-Al_2O_3 (EP-A-0449089), Cu supported on Al_2O_3 (Barrault et al., Rev. Fr. Corps Gras 1991, 38, 103) or Fe (CA-A-0907059).

However, a heterogeneous reaction has, in principle, considerable disadvantages (J. Hagen, Technische Katalyse, VCH, Weinheim, 1996, p. 10). It has been found that characteristic problems occur in the mass transfer between the phases and result in an appreciable reduction in the reaction rate. For this reason, high reaction temperatures of up to 150°C and pressures of up to 250 bar are usually necessary for the

heterogeneously catalyzed amination. This represents a considerable economic disadvantage in the construction and operation of such plants.

The development of new catalysts which make it possible to carry out the desired reaction under milder conditions is therefore of exceptional interest. Furthermore, tolerance of further functional groups which are usually present in the molecule, e.g. in the synthesis of active compounds, is significantly restricted because of the drastic reaction conditions. In addition, the heterogeneous catalysts can be characterized only with difficulty, a fact which can seriously impair the reproducibility of the catalysis results and make rational catalyst design or modification to meet specific objectives difficult or even impossible.

Only very few examples of catalysts in homogeneous systems are known in the literature: dimethylglyoximate complexes of cobalt and rhodium (M.V. Klyuev, M.L. Khidekel, Transition Met. Chem., 1980, 5 134-139). To activate the catalysts, almost stoichiometric amounts of sodium borohydride have to be used. Furthermore, Rh and Co carbonyl complexes (L. Marko, J. Bakos Journal of Organometallic Chemistry, 1974, 81, 411-414) and cobalt-cyano-complexes (M. Murakami, J.-W. Kang Bull. Chem. Soc. Japan, 1963, 36, 763-768) have been described. However, owing to the large amounts of catalyst and the drastic conditions required, the processes described are not practical.

JP 11-343269 describes the synthesis of octylamine from octanal and ammonia, in which a series of homogeneous catalysts such as iron(II) sulfide, nickel acetylacetonate, carbonylrhodium acetylacetonate, palladium acetylacetonate, dodecacarbonylosmium(III), hexacarbonylindium(VI), 1,5-cyclooctadieneplatinum dichloride and ruthenium acetylacetonate with 2,2'-bipyridyl in an extremely complicated process at a high temperature of 150°C. The hydroaminomethylation reaction (P. Eilbracht et al. Chem. Rev. 1999, 99, 3329-3364), for which a reductive amination of an intermediate has been postulated but not proven to date, also proceeds under drastic reaction conditions.

It is therefore an object of the present invention to find a process by means of which the amination can be carried out under mild conditions and the abovementioned problems can be avoided.

Furthermore, the process should also allow the synthesis of enantiomerically pure or enantiomerically enriched amines by use of chirally modified catalysts.

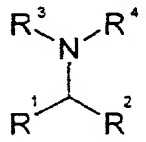
It has now surprisingly been found that the desired amines can be obtained very efficiently by the reductive amination of ketones and aldehydes in the presence of catalytically active transition metal complexes based on phosphorus-containing ligands under very mild conditions.

Under these mild reaction conditions, an enantioselective reaction is possible when using chiral ligands.

The transition metal catalysts used give good to very good yields of the desired amine in the reductive amination. At the same time, a very high amine/alcohol ratio in the products can be achieved.

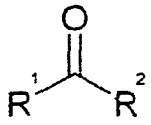
The process of the invention overcomes the known disadvantages of the metal-catalyzed reductive aminations described hitherto.

The present invention accordingly provides a process for preparing amines of the formula (III)



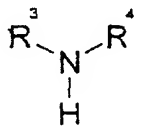
(III)

by reacting a compound of the formula (I)



(I)

with a compound of the formula (II)



(II)

where the radicals R^1 to R^4 are selected independently from the group consisting of hydrogen, (C_1-C_{24})-alkyl, (C_2-C_{24})-alkenyl, (C_2-C_{24})-alkynyl, (C_6-C_{10})-aryl, CF_3, CN, COOH, COOM, where M is a cation, CHO, SO_3H, COO-alkyl-(C_1-C_8), $CONH_2$, CONHalkyl-(C_1-C_8), CONalkyl$_2$-(C_1-C_8), CO-alkyl-(C_1-C_8), CO-phenyl, COO-phenyl, COO-aryl-(C_6-C_{10}), CO-aryl-(C_6-C_{10}), P(aryl)$_2$, Palkyl$_2$-(C_1-C_8), PO(aryl)$_2$, POalkyl$_2$-(C_1-C_4), PO_3H_2, POalkyl-(C_1-C_4)(O-alkyl-(C_1-C_6)), PO(O-alkyl-(C_1-C_6))$_2$, SO_3-alkyl-(C_1-C_4), SO_2-alkyl-(C_1-C_6), SO-alkyl-(C_1-C_6) or Si(alkyl)$_3$-(C_1-C_8), and/or R^3 and R^4 are selected independently from the group consisting of O-alkyl-(C_1-C_8), OCO-alkyl-(C_1-C_8), O-aryl, fluorine, OH, NH_2, NH-alkyl-(C_1-C_8), N-alkyl$_2$-(C_1-C_8), NHCO-alkyl-(C_1-C_4), NHaryl-(C_6-C_{10}), NHCOO-alkyl-(C_1-C_4),

where alkyl is, for the purposes of the present invention, an unbranched or branched aliphatic or cyclic or heterocyclic radical containing at least one (1-4) nitrogen, sulfur or oxygen atom, alkenyl is an olefinic hydrocarbon, alkynyl is an acetylenic hydrocarbon and aryl is an aromatic radical which may also be an aromatic containing at least one (1-4) nitrogen, sulfur or oxygen atom. Alkyl, alkenyl, alkynyl and also aryl may bear substituents selected independently from among hydrogen, O-alkyl-(C_1-C_8), OCO-alkyl-(C_1-C_8), O-phenyl, phenyl, aryl(C_6-C_{10}), fluorine, chlorine, bromine, iodine, OH, NO_2, CF_3, CN, COOH, COOM, where M is a cation (Li^+, Na^+, K^+, Mg^{2+}, Ca^{2+}, NH_4^+, N(C_1-C_{10}-alkyl)$_4^+$, N(C_1-C_{10}-alkyl/C_6-C_{10}-aryl)$_4^+$), CHO, SO_3H, NH_2, NH-alkyl-(C_1-C_8), N-alkyl$_2$-(C_1-C_8), NHCO-alkyl-(C_1-C_4), COO-alkyl-(C_1-C_8), $CONH_2$, CO-alkyl-(C_1-C_8), NHCOH, NHCOO-alkyl-(C_1-C_4), CO-phenyl, COO-phenyl, COO-aryl-(C_6-C_{10}), CO-aryl-(C_6-C_{10}), CHCH-CO_2-alkyl-(C_1-C_8), P(aryl)$_2$, $CHCHCO_2H$, P-alkyl$_2$-(C_1-C_8), PO-aryl$_2$, POalkyl$_2$-(C_1-C_4), PO_3H_2, POalkyl-(C_1-C_4)(O-alkyl-(C_1-C_6)), PO(O-alkyl-(C_1-C_6))$_2$, SO_3-alkyl-(C_1-C_4), SO_2-alkyl-(C_1-C_6), SO-alkyl-(C_1-C_6) or Si(alkyl)$_3$-(C_1-C_8).

Both R^1 and R^2 and also R^3 and R^4 can be linked by covalent bonds so that R^1 and R^2 and/or R^3 and R^4 in each case form a four- to eight-membered ring. R^1 or R^2 may also be part of an organometallic compound.

The reaction is carried out in the presence of hydrogen and a homogeneous catalyst system comprising at least one metal atom selected

from the group consisting of Rh, Ru, Ir, Pd, Pt, Co and Ni and one or more monodentate or bidentate achiral or chiral ligands of the formula (IV) or (V)

$$(R^6Y^1)(R^7Y^1)P^1X^1ZX^2P^2(Y^2R^8)(Y^2R^9) \quad (IV)$$

$$(R^6Y^1)(R^7Y^1)(R^8Y^1)P \quad (V)$$

where

R^6 to R^9 are identical or different and are a hydrogen atom or a C_1-C_{50} group, e.g. C_1-C_{24}-alkyl, C_2-C_{20}-alkenyl, C_3-C_8-cycloalkyl, C_5-C_8-cycloalkenyl, C_6-C_{14}-aryl, phenyl, naphthyl, fuorenyl, C_2-C_{13}-heteroaryl, where the number of heteroatoms from the groups consisting of N, O, S can be 1-4, where the cyclic aliphatic or aromatic radicals are preferably 5- to 7-membered rings,

and in which all the abovementioned substituents may each be substituted by one or more substituents selected independently from among hydrogen, C_1-C_{20}-alkyl, C_2-C_{20}-alkenyl, C_1-C_{10}-haloalkyl, C_3-C_8-cycloalkyl, C_5-C_8-cycloalkenyl, C_2-C_9-heterocycloalkyl, C_1-C_9-heterocycloalkenyl, C_6-C_{14}-aryl, phenyl, C_2-C_{13}-heteroaryl, where the number of heteroatoms from the group consisting of N, O, S can be 1-4, C_1-C_{10}-alkoxy, OCO-alkyl-(C_1-C_8), O-aryl-(C_5-C_{10}), O-phenyl, C_1-C_9-trihalomethylalkyl, fluoro, chloro, bromo, iodo, nitro, hydroxy, trifluoromethylsulfonato, oxo, thio, thiolato, amino, C_1-C_8-substituted amino of the types mono- and di-C_1-C_8-alkylamino or C_2-C_8-alkenylamino or mono-, di-, tri-C_6-C_8-arylamino or C_1-C_8-alkyl-C_6-C_8-arylamino, NH-CO-alkyl-C_1-C_8, NH-CO-aryl-C_6-C_8, cyano, C_1-C_8-acyloxy, carboxyl, carboxylato of the formula $COOR^{12}$, sulfinato, sulfonato of the formula SO_3R^{12}, phosphonato of the formula PO_3H_2, PO_3HR^{12}, $PO_3R^{12}{}_2$, where R^{12} is either a monovalent cation, NH_4^+, $N(C_1$-C_{10}-alkyl$)_4^+$, $N(C_1$-C_{10}-alkyl/C_6-C_{10}-aryl$)_4^+$, C_1-C_{18}-alkyl or C_6-aryl, tri-C_1-C_6-alkylsilyl,

and where two of these substituents may also be bridged, and R^6 and R^7 and/or R^8 and R^9 may also be linked by a covalent bond so as to form a cyclic compound having from four to eight atoms,

X^1 and X^2 are each, independently of one another, a direct phosphorus-carbon bond, O, S or NR^{10}, where

R^{10} corresponds to one of the radicals defined for R^6-R^9,

Y^1 and Y^2 is a direct phosphorus-carbon bond, -O- or -NR^{11}-, where

R^{11} corresponds to one of the radicals defined for R^6-R^9,

Z corresponds to 1-6 carbon atoms which are bound to one another by single or multiple bonds and connect the unit $(R^6Y^1)(R^7Y^1)PX^1$ to the unit $X^2P(Y^2R^8)(Y^2R^9)$, where Z may be part of an aliphatic, cycloaliphatic, olefinic, cycloolefinic system which may contain from one to four heteroatoms from the group consisting of N, O, S, a metallocene, in particular a ferrocene, a 1,1'-disubstituted ferrocene, 1-(1-ethylenyl)-2-ferrocenyl or a 1,2-disubstituted ferrocene, or one or more aromatic or heteroaromatic ring systems, where the ring system comprises a total of from 2 to 14 carbon atoms which may be monosubstituted or polysubstituted by substituents as specified for R^6-R^9 or directly by C_1-C_{10}-alkoxy, OCO-alkyl-(C_1-C_8), O-aryl-(C_5-C_{10}), O-phenyl, C_1-C_9-trihalomethylalkyl, trifluoromethyl, trichloromethyl, fluoro, chloro, bromo, iodo, nitro, hydroxy, trifluoromethylsulfonato, oxo, thio, thiolato, amino, C_1-C_8-substituted amino of the formulae NH_2, NH-alkyl-C_1-C_8, NH-aryl-C_5-C_6, N-alkyl$_2$-C_1-C_8, N-aryl$_2$-C_5-C_6, N-alkyl$_3$-C_1-C_8^+, N-aryl$_2$-C_5-C_6-aryl-C_5-C_6^+, C_1-C_6-acyloxy, carboxylato of the formulae COOH and $COOR^{12}$, sulfinato, sulfonato of the formulae SO_3H and SO_3R^{12}, phosphonato of the formulae PO_3H_2, PO_3HR^{12} and $PO_3R^{12}{}_2$, where R^{12} is either a monovalent cation, NH_4^+, $N(C_1$-C_{10}-alkyl$)_4^+$, $N(C_1$-C_{10}-alkyl/C_6-C_{10}-aryl$)_4^+$, C_1-C_8-alkyl or C_6-aryl, C_1-C_6-trialkylsilyl, NHCO-alkyl-(C_1-C_4), COO-alkyl-(C_1-C_8), $CONH_2$, CON(alkyl-(C_1-C_8))$_2$, CO-alkyl-(C_1-C_8), CO-alkenyl-(C_1-C_8), NHCOO-alkyl-(C_1-C_4), CO-aryl-(C_6-C_{10}), CO-phenyl, COO-aryl-(C_6-C_{10}), COO-phenyl, CHCH-CO_2-alkyl-(C_1-C_8), $CHCHCO_2H$, and

P is a trivalent phosphorus atom.

In a preferred embodiment, R^1 to R^4 are each, independently of one another, hydrogen, (C_1-C_{12})-alkyl, (C_2-C_{12})-alkenyl, (C_2-C_{12})-alkynyl, (C_6-C_{10})-aryl, CF_3, CN, COOH, COOM, where M is a cation (Li^+, Na^+, K^+,

Mg^{2+}, Ca^{2+}, NH_4^+, $N(C_1\text{-}C_{10}\text{-alkyl})_4^+$, $N(C_1\text{-}C_{10}\text{-alkyl/}C_6\text{-}C_{10}\text{-aryl})_4^+$), COO-alkyl-($C_1$-$C_8$), $CONH_2$, CO-alkyl-(C_1-C_8), CO-phenyl, COO-phenyl, COO-aryl-(C_6-C_{10}), CO-aryl-(C_6-C_{10}), PO(aryl-C_6-C_{10})$_2$, POalkyl$_2$-(C_1-C_4), PO_3H_2, PO(alkyl-(C_1-C_4))(Oalkyl-(C_1-C_4)), PO(O-alkyl-(C_1-C_6))$_2$ or Si(alkyl)$_3$-(C_1-C_8) and/or R^3 and R^4 are selected independently from the group consisting of O-alkyl-(C_1-C_8), OCO-alkyl-(C_1-C_8), O-aryl(C_6-C_{10}), OH, NH_2, NH-alkyl-(C_1-C_8), N-alkyl$_2$-(C_1-C_8), NHCO-alkyl-(C_1-C_4), NHCOO-alkyl-(C_1-C_4),

where alkyl is an unbranched or branched aliphatic or cyclic or heterocyclic (containing at least one nitrogen or oxygen atoms (1-4)) radical, alkenyl is an olefinic hydrocarbon, alkynyl is an acetylenic hydrocarbon and aryl is an aromatic radical which may also be an aromatic containing at least (1-4) one nitrogen, oxygen and/or sulfur atom. Alkyl, alkenyl and alkynyl and also aryl may bear substituents selected independently from among hydrogen, O-alkyl-(C_1-C_8), OCO-alkyl-(C_1-C_8), O-phenyl, phenyl, aryl-C_6-C_{10}, fluorine, chlorine, bromine, iodine, OH, NO_2, Si-alkyl$_3$-(C_1-C_8), CF_3, CN, COOH, COOM, where M is a monovalent cation selected from the group consisting of Na, K, Rb, Cs, NH_4, $N(C_1\text{-}C_{10}\text{-alkyl})_4$, $N(C_1\text{-}C_{10}\text{-alkyl/}C_6\text{-}C_{10}\text{-aryl})_4$, and SO_3H, N-alkyl$_2$-(C_1-C_8), SO_2-alkyl-(C_1-C_6), SO-alkyl-(C_1-C_6), NHCO-alkyl-(C_1-C_4), COO-alkyl-(C_1-C_8), $CONH_2$, CO-alkyl-(C_1-C_8), CO-phenyl, COO-phenyl, COO-aryl-(C_6-C_{10}), CO-aryl-(C_6-C_{10}), PO-phenyl$_2$, POalkyl$_2$-(C_1-C_4), PO_3H_2, POalkyl-(C_1-C_4)(O-alkyl-(C_1-C_6)), PO(O-alkyl-(C_1-C_6))$_2$, Si(alkyl)$_3$-(C_1-C_8), where alkyl and aryl are as defined above.

Both R^1 and/or R^2 and also R^3 and R^4 may be linked by covalent bonds so as to form a five- to seven-membered ring. R^1 or R^2 may also be part of an organometallic compound, in particular part of a ferrocene-containing molecule.

As homogeneous metal atom-ligand complex, preference is given to using metal complexes having central atoms from the group consisting of Rh, Ru, Ir, Pd, Pt, Ni, in particular those which contain rhodium or iridium as central atom.

Preferred ligands are ligands of the formula (IV), among which further preference is given to those in which R^6 to R^9 are each, independently of one another, C_1-C_8-alkyl, C_5-C_6-cycloalkyl, C_6-aryl, C_4-C_5-heteroaryl, where the number of heteroatoms is 1-2, selected from the group

consisting of N, O, S, and the ring size is 5-6, or are naphthyl, with these groups being able to bear one or more substituents, preferably substituents selected independently from among hydrogen, C_1-C_{10}-alkyl, C_1-C_6-haloalkyl, C_5-C_6-cycloalkyl, C_2-C_9-heterocycloalkyl, C_6-aryl, phenyl, C_4-C_5-heteroaryl, where the number of heteroatoms from the group consisting of N, O, S, can be 1-2, C_1-C_6-alkoxy, OCO-alkyl-(C_1-C_6), O-aryl-C_6, C_1-C_6-trihalomethylalkyl, fluoro, chloro, bromo, iodo, nitro, hydroxy, oxo, thio, thiolato, amino, C_1-C_8-substituted amino of the types mono-, di-, tri-C_1-C_8-alkylamino or C_2-C_8-alkenylamino or mono- and di-C_6-C_8-arylamino or C_1-C_8-alkyl-C_6-C_8-arylamino, NH-CO-alkyl-C_1-C_8, NH-CO-aryl-C_6-C_8, C_1-C_8-acyloxy, carboxyl, carboxylato of the formula $COOR^{12}$, sulfinato, sulfonato of the formula SO_3R^{12}, phosphonato of the formula PO_3H_2, PO_3HR^{12}, $PO_3R^{12}{}_2$, where R^{12} can be either a monovalent or divalent cation (Li^+, Na^+, K^+, Mg^{2+}, Ca^{2+}), NH_4^+, $N(C_1\text{-}C_{10}\text{-alkyl})_4^+$, $N(C_1\text{-}C_{10}\text{-alkyl/}C_6\text{-}C_{10}\text{-aryl})_4^+$, C_1-C_8-alkyl or C_6-aryl, and tri-C_1-C_6-alkylsilyl.

Preference is also given to ligands in which Y^1 and Y^2 are each a direct phosphorus-carbon bond and in which Z comprises from one to four carbon atoms, particularly preferably two carbon atoms.

Particular preference is given to systems in which a seven-membered ring can be formed from Z, X^1, X^2, P^1 and P^2 together with a coordinated metal.

Z is preferably a C_1-C_6-alkyl or C_2-C_6-alkenyl group or is part of a C_3-C_8-cycloalkyl, C_5-C_8-cycloalkenyl, C_2-C_9-heterocycloalkyl, C_1-C_9-heterocycloalkenyl, C_6-C_{14}-aryl, phenyl, naphthyl, fluorenyl, C_2-C_{13}-heteroaryl group, where the number of heteroatoms from the group consisting of N, O, S can be 1-4,
where all these groups may be monosubstituted or polysubstituted as described above.

If Z is part of a cyclic structural element, three- to nine-membered ring systems are preferred. Particular preference is given to five- to seven-membered ring systems. The ring system may contain from one to four heteroatoms from the group consisting of N, O, S, preferably one or two. The nitrogen of the ring system can be present as NR^{10}, $NR^{10}R^{11+}$, $NR^{10}H^+$, $NC(O)R^{10}$. The ring systems can be monosubstituted or polysubstituted as indicated for R^6 to R^9 or directly by alkoxy, halo, nitro, hydroxy, oxo, thio, thiolato, amino, substituted amino, cyano, sulfonato,

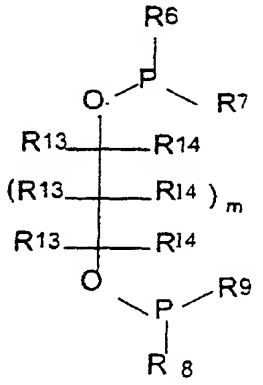
phosphonato, trialkylsilyl groups, where the substituents may also be bridged to one another.

Particularly preferred ring systems are phenyl, ferrocenyl, cyclopentyl, cyclohexyl, pyridyl, pyrrole, furyl, thiophene, tetrahydrofuran, tetrahydrothiophene, piperidyl, pyrrolidinyl, dioxolane or sulfolane rings which may each be unsubstituted or substituted as described above.

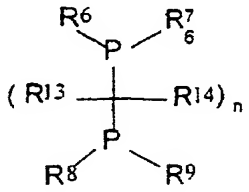
For the purposes of the present invention, metallocenes such as ferrocenes are formally included in the group of aromatics.

The ligand system used according to the invention preferably comprises, in R^6-R^{12}, independently of one another, alkyl, cycloalkyl or/and aryl which each contain from 1 to 20, in particular from 1 to 6, carbon atoms.

Examples of achiral or chiral ligands are compounds of the formulae VI, VII, VIII, IX, X and XI,



(VI)



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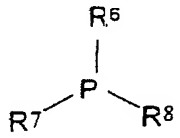
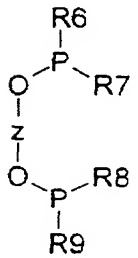


(VIII)



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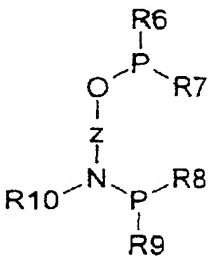
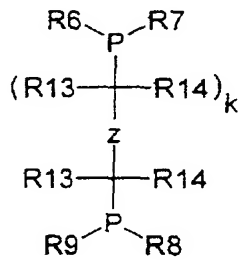


(X)



(XI)

where R^6 to R^{10} and R^{13}, R^{14} are each, independently of one another, hydrogen, (C_1-C_{24})-alkyl, (C_6-C_{10})-aryl, O-(C_1-C_{24})-alkyl or O-(C_6-C_{10})-aryl and R^6 and R^7 and/or R^8 and R^9 may also be linked by a covalent bond so as to form a cyclic compound having from four to eight atoms, and m is 0, 1 or 2, n is 1, 2, 3, 4, 5 or 6 and k is 0 or 1.

Z is as defined above.

For the purposes of the present invention, alkyl is an unbranched or branched aliphatic or cyclic hydrocarbon and aryl is an aromatic radical which may also be an aromatic containing at least one nitrogen or oxygen atom.

Ligands of the formulae (VI) to (XI) include, for example, ones in which R^6 to R^9 and R^{13}, R^{14} are selected independently from the group consisting of (C_3-C_8)-alkyl, (C_6-C_{10})-aryl, O-(C_5-C_8)-alkyl, O-(C_6-C_{10})-aryl, where alkyl is an unbranched or branched aliphatic or cyclic hydrocarbon and aryl is an aromatic radical, and m is from zero to two and n is from one to six. Both alkyl and aryl may bear substituents selected independently from among hydrogen, O-alkyl-(C_1-C_8), O-phenyl, phenyl, aryl, fluorine, chlorine, OH, NO_2, Si-alkyl$_3$-(C_1-C_4), CF_3, CN, SO_3H, N-alkyl$_2$-(C_1-C_4), CO-phenyl, COO-phenyl, COO-aryl-(C_6-C_{10}), CO-aryl-(C_6-C_{10}), PO-phenyl$_2$, POalkyl$_2$-(C_1-C_4), PO(O-alkyl-(C_1-C_6))$_2$, Si(alkyl)$_3$-(C_1-C_8), where alkyl and aryl are as defined above.

In these ligands, R^6 and R^7 and/or R^8 and R^9 may also be linked by a covalent bond so as to form a cyclic compound having from five to seven atoms.

Typical representatives of the ligand systems used in the process of the invention are phosphine and diphosphine ligands and modifications of this ligand type, for example dppb (1,4-bis(diphenylphosphino)butane), dcypb (1,4-bis(dicyclohexylphosphino)butane), bppm (2-diphenylphosphinomethyl-4-diphenylphosphino-1-tert-butoxycarbonylpyrrolidine), diop (2,3-O-isopropylidene-2,3-dihydroxy-1,4-bis(diphenylphosphino)butane) (Kagan et al., J. Amer. Chem. Soc. (1972), 94, 6429), (2*R*,3*R*,5*R*,6*R*)-2,3-dimethoxy-2,3-dimethyl-5,6-bis(diphenylphosphinomethyl)-1,4-dioxane (Berens et al., J. Org. Chem. (1995), 60, 8204), TPPTS (tris-(3-sulfophenyl)phosphine

trisodium salt) (Herrmann et al., Angew. Chem., Int. Ed. Engl. (1995), 34, 811), BINAS (2,2'-bis[[bis(3-sulfophenyl)phosphino]methyl]-4,4',7,7'-tetrasulfo-1,1'-binaphthyl octasodium salt) (Herrmann et al., Inorg. Synth. (1998), 32, 8), diphosphinite ligands based on carbohydrates as described, for example, in DD 140036 and WO 95/18787 and related ligand systems such as dpoe (1,2-bis(diphenylphosphinoxy)ethane), bdpch ((1*R*,2*R*)-(trans)-1,2-bis-(diphenylphosphinoxy)cyclohexane) and aminophosphine phosphinites (Agbossou et al., Coordination Chemistry Rev. 1998, 178-180, 1615), e.g. the PROPRAHOS analog (2*R*)-1-[[(diphenylphosphino)(cyclopenthyl)amino]methyl]-2-diphenylphosphinoxy-3-(1-naphthalenyloxy)propane (Krause et al., J. Mol. Catal. A: Chem. (1995), 104, 147) and aminophosphines, e.g. (4*S*)-2-(2-(diphenylphosphino)phenyl)-4-isopropyl-1,3-oxazoline (Koch G., Lloyd-Jones G.C., Loiseleur O., Pfaltz A., Pretot R., Schaffner S., Schnider P., von Matt P. Recl. Trav. Chim. Pays-Bas 1995, 114, 206-10).

The phosphorus-containing ligands can be prepared under conditions with which those skilled in the art are familiar (for example by methods as are described in Chemistry of Organophosphorus Compounds, Ed. F. R. Hartley, Serial Ed. S. Patai, Vol. 1, John Whiley, 1990). Some of the ligands and/or metal complexes are commercially available (for example from Aldrich or Strem/ABCR).

The catalytically active metal complexes can be synthesized by, for example, reacting the phosphorus-containing ligands in a known manner (EP-A-0158875; EP-A-0437690) with rhodium, iridium, ruthenium, palladium, platinum, cobalt or nickel complexes containing labile ligands (e.g. $[Rh(COD)_2]BF_4$, $[RuCl_2(COD)]_n$, $[Ir(COD)Cl]_2$). Furthermore, all methods with which an organometallic chemist is familiar can be utilized for generating appropriate complexes.
The catalysts can be produced in situ from the metal precursor and the ligand, or they are used in isolated form.

The process of the invention is generally carried out at a temperature of -40-100°C, preferably at -20-60°C.

The initial hydrogen pressure in the process of the invention can be varied in a wide range from 0.1 bar to 300 bar. The process is preferably carried out at 1 bar – 100 bar, particularly preferably from 20 to 60 bar.

It can be advantageous to carry out the process of the invention in the presence of additives.

Additives are acids such as p-toluenesulfonic acid, tetrafluoroboric acid, phosphoric acid, sulfuric acid or acetic acid, bases such as sodium hydroxide, potassium hydroxide, tertiary amines, proton sponges, cesium carbonate, acetate or sodium carbonate, salts such as halides of the alkali metals or ammonium halides, phase transfer catalysts, surfactants or cyclodextrins, which are employed in amounts of 0 – 100 mol% based on the amine (II) used.

Preferred solvents for the reductive amination are alcohols, in particular C_1-C_6-alkanols, particularly preferably methanol, ethanol, propanol, isopropanol, or else water and mixtures thereof. In the case of sparingly soluble substrates, solvent mixtures of alcohols and halogenated hydrocarbons and/or ethers, in particular cyclic ethers such as THF, and/or aromatic hydrocarbons such as toluene are also useful.

The process can also be carried out in a 2-phase system as described, for example, in DE 19737053.

The catalyst is usually used in amounts of from 0.001 to 5 mol%, preferably from 0.001 to 0.01 mol%, based on the carbonyl component of the formula (I).

The following examples illustrate the invention without restricting it to them.

Example 1

In an autoclave, a solution of 5.0 mmol of acetophenone, 5.0 mmol of piperidine and 0.01 mmol of $Rh[(dppb)(COD)]BF_4$ in 10 ml of methanol was stirred at room temperature and an initial hydrogen pressure of 51-52 bar for 19.7 hours. Under these conditions, 25.4% of the ketone were reacted. The ratio of 1-N-piperidinylethylbenzene to 1-phenylethylcarbinol in the product determined by ^{1}H-NMR spectroscopy was 1/10 (cf. Table 1).

Example 2

In an autoclave, a solution of 5.0 mmol of acetophenone, 5.0 mmol of piperidine, 0.2 mmol of p-toluenesulfonic acid and 0.01 mmol of

$Rh[(dppb)(COD)]BF_4$ in 10 ml of methanol was stirred at room temperature and an initial hydrogen pressure of 51-52 bar for 16 hours. Under these conditions, 5.6% of the ketone were reacted. The ratio of 1-N-piperidinylethylbenzene to 1-phenylethylcarbinol in the product was 2/1 (cf. Table 1).

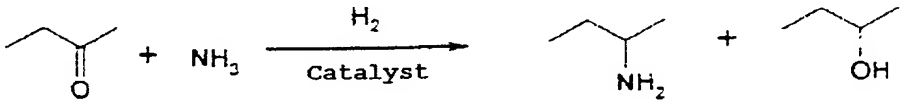
Example 3

In an autoclave, a solution of 5.0 mmol of acetophenone, 5.0 mmol of benzylamine and 0.01 mmol of $Rh[(dppb)(COD)]BF_4$ in 10 ml of methanol was stirred at room temperature and an initial hydrogen pressure of 51-52 bar for 20 hours. Under these conditions, 10.7% of the ketone were reacted. The ratio of 1-N-piperidinylethylbenzene to 1-phenylethylcarbinol in the product was 1/10 (cf. Table 1).

Example 4

A solution of 60 mmol of acetophenone in 40 ml of toluene, 40 ml of 25% strength aqueous ammonia solution, 0.15 mmol of $[Ir[(COD)Cl]_2$ and 6 ml of a 0.1 molar solution of 2,2'-bis[[bis(3-sulfophenyl)phosphino]methyl]-4,4',7,7'-tetrasulfo-1,1'-binaphthyl octasodium salt (BINAS) were introduced into a 300 ml autoclave provided with an intensive magnetic stirrer and were stirred at 130°C and an initial hydrogen pressure of 46 bar. After 13 hours, the autoclave was cooled and vented, the organic phase was dried over $MgSO_4$ and analyzed by gas chromatography. After evaporation of the solvent, the residue was examined by NMR spectroscopy. At a conversion of 38%, the ratio of 1-phenylethylamine to 1-phenylethanol was found to be 7/31 (cf. Table 1).

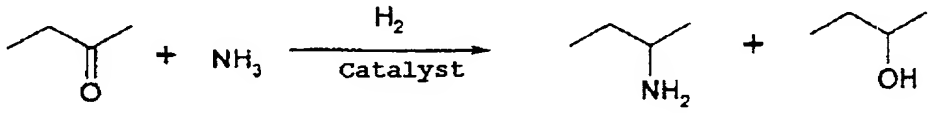
Example 5



A solution of 60 mmol of 2-octanone in 40 ml of heptane, 40 ml of 25% strength aqueous ammonia solution, 0.15 mmol of $[Ir[(COD)Cl]_2$, 2.4 mmol of partially methylated β-cyclodextrin from Cyclolab (Budapest, Hungary) and 6 ml of a 0.1 molar solution of 2,2'-bis[[bis(3-sulfophenyl)phosphino]-methyl]-4,4',7,7'-tetrasulfo-1,1'-binaphthyl octasodium salt (BINAS) were

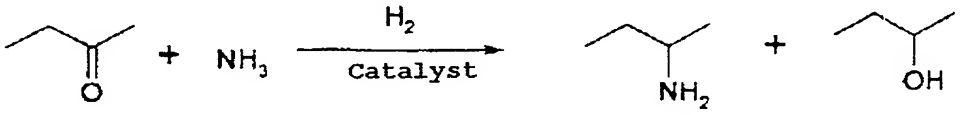
introduced into a 300 ml autoclave provided with intensive magnetic stirring and were stirred at 130°C and an initial hydrogen pressure of 89 bar. After 7 hours, the autoclave was cooled and vented, the organic phase was dried over $MgSO_4$ and analyzed by gas chromatography. After evaporation of the solvent, the residue was examined by NMR spectroscopy. At a conversion of 10%, the ratio of 2-octylamine to 2-octanol was found to be 7/3.

Example 6



0.15 mol of butanone, 60 ml of 25% strength aqueous ammonia solution, 0.15 mmol of $[Ir[(COD)Cl]_2$ and 6 ml of a 0.1 molar solution of BINAS were introduced into a 100 ml autoclave provided with intensive magnetic stirring and were stirred at 130°C and an initial hydrogen pressure of 110 bar. After 5 hours, the autoclave was cooled and vented, and the aqueous solution was examined by NMR spectroscopy. At a conversion of 80%, the ratio of 2-butylamine to 2-butanol was found to be 1/2. The proportion of the secondary amine was 6%.

Example 7



0.15 mol of butanone, 50 ml of 25% strength aqueous ammonia solution, 0.15 mmol of $[Rh[(COD)Cl]_2$ and 6 ml of a 0.1 molar solution of BINAS were introduced into a 100 ml autoclave provided with an intensive magnetic stirrer and were stirred at 100°C and an initial hydrogen pressure of 63 bar. After 7 hours, the autoclave was cooled and vented, the aqueous solution (13% of starting material, 14% of 2-butanol and 73% of 2-butylamine) was extracted with ether a number of times, the organic phase was dried over caustic potash and fractionated via a 30 cm Vigreux

column. The fraction between 55 and 66°C (10.2 g) had a content of the desired 2-butylamine of 30% (GC analysis).

Examples 8 to 13

These examples were carried out in a manner analogous to Examples 1-3. Amine components, catalysts and the results of the reaction are indicated in Table 2.

Example 14

In a 100 ml autoclave fitted with a dropping funnel, 5.1 ml (50 mmol) of benzaldehyde were admixed with 20 ml of methanol which had been saturated with ammonia at 10°C. The autoclave was closed, pressurized with 91 bar of hydrogen and heated to 80°C. A solution of 0.05 mmol of $[Rh(dcypb)]BF_4$ in 10 ml of methanol was subsequently added from the dropping funnel and the mixture was stirred at 80°C for another 2 hours. After cooling and evaporation of the solvent, the residue was analyzed by gas chromatography and NMR spectroscopy. At a conversion of above 99%, the ratio of benzylamine to dibenzylamine to benzyl alcohol was found to be 25/32/43.

Example 15

0.2 ml (2 mmol) of benzaldehyde were dissolved in 2 ml of heptane and, after addition of a solution of 23 mg (0.04 mmol) of tris-(3-sulfophenyl)phosphine trisodium salt (TPPTS) and 7.2 mg (0.02 mmol) of $[Rh[(C_8H_{14})_2Cl]_2$ in 2 ml of 25% strength aqueous ammonia solution, hydrogenated at 46 bar and 90°C while stirring vigorously in an autoclave. After 8 hours, the autoclave was cooled and vented, the organic phase was dried over $MgSO_4$ and analyzed by gas chromatography. At a conversion of above 99%, the ratio of benzylamine to dibenzylamine to benzyl alcohol was found to be 52/20/18.

Example 16

This example was carried out in a manner analogous to Example 14. The reaction conditions and results are reported in Table 2.

Example 17

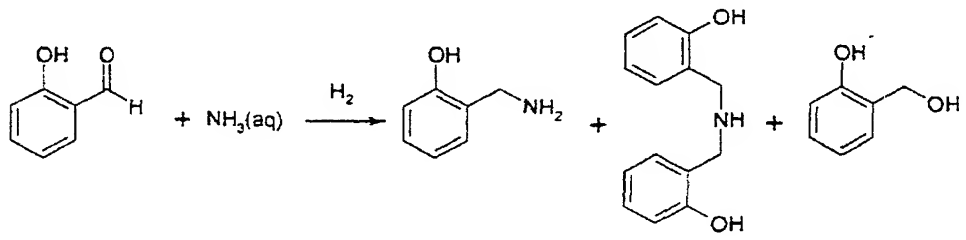
In a 100 ml autoclave fitted with a dropping funnel, a solution of 5.1 ml (50 mmol) of benzaldehyde in 15 ml of ethanol was admixed with 20 ml of 25% strength ammonia solution. The autoclave was closed, pressurized

with 78 bar of hydrogen and heated to 100°C. A solution of 0.1 mmol of $[Rh(dppb)]BF_4$ in 10 ml of methanol was subsequently added from the dropping funnel and the mixture was stirred at 100°C for another 2 hours. After cooling and evaporation of the solvent, the residue was analyzed by gas chromatography and NMR spectroscopy. At a conversion of above 99%, the ratio of benzylamine to benzyl alcohol was found to be 15/85.

Example 18

In a 100 ml autoclave fitted with a dropping funnel, a solution of 5.1 ml (50 mmol) of benzaldehyde in 10 ml of methanol was admixed with 20 ml of 25% strength ammonia solution. The autoclave was closed, pressurized with 69 bar of hydrogen and heated to 90°C. A solution of 0.05 mmol of $[Rh[(COD)Cl]_2$ and 0.2 mmol of 2,2'-bis[[bis(3-sulfophenyl)phosphino]methyl]-4,4',7,7'-tetrasulfo-1,1'-binaphthyl octasodium salt (BINAS) in 5 ml of 5% strength aqueous ammonia solution was subsequently added from the dropping funnel and the mixture was stirred at 90°C for another 1.5 hours. After cooling and evaporation of the solvent, the residue was analyzed by gas chromatography and NMR spectroscopy. At a conversion of 99%, the ratio of benzylamine to dibenzylamine to benzyl alcohol was found to be 58/25/17.

Example 19



In a 100 ml autoclave fitted with a dropping funnel, a solution of 5.3 ml (50 mmol) of salicylaldehyde in 30 ml of ethanol was added dropwise to 10 ml of 25% strength ammonia solution while stirring. The autoclave was closed, pressurized with 58 bar of hydrogen and heated to 90°C. A solution of 0.05 mmol of $[Rh[(COD)Cl]_2$ and 0.2 mmol of 2,2'-bis[[bis(3-sulfophenyl)phosphino]methyl]-4,4',7,7'-tetrasulfo-1,1'-binaphthyl octasodium salt (BINAS) in 5 ml of 5% strength aqueous ammonia solution was subsequently added from the dropping funnel and the mixture was stirred at 90°C for another 10 hours. After cooling and evaporation of the solvent,

the residue was analyzed by NMR spectroscopy. At a conversion of 96%, the ratio of o-hydroxybenzylamine to di(o-hydroxybenzyl)amine was found to be 51/45.

Example 20

In a 30 ml autoclave fitted with a dropping funnel, a solution of 0.01 mmol of $Rh[(dppb)COD]BF_4$ in 5 ml of methanol was hydrogenated at room temperature and a hydrogen pressure of 50 bar for 15 minutes. A solution of 5 mmol of 4-hydroxybenzaldehyde and 10 mmol of piperidine in 10 ml of methanol was subsequently added from the dropping funnel and hydrogenation was continued for a further 2 hours. After evaporation of the solvent, the residue was examined by NMR spectroscopy. At a conversion of above 99%, the ratio of N-(4-hydroxybenzyl)piperidine to 4-hydroxybenzyl alcohol was found to be 94/1.

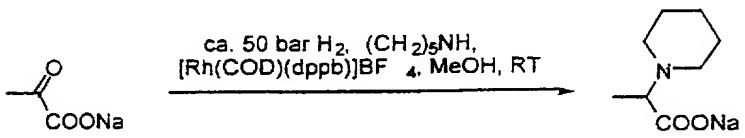
Examples 21 to 28

These examples were carried out in a manner analogous to Example 20. Aldehydes and the results of the reactions are reported in Table 3.

Examples 29 to 34

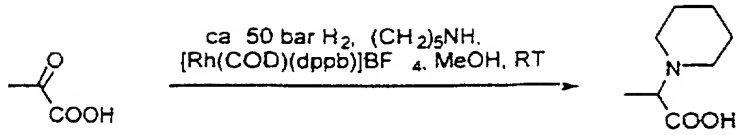
These examples were carried out in a manner analogous to Example 1. Catalysts and the results of the reactions are reported in Table 4.

Example 35



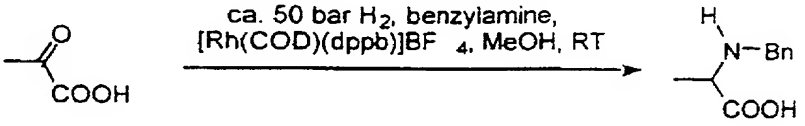
In an autoclave, a solution of 5.0 mmol of sodium pyruvate, 5.0 mmol of piperidine and 0.01 mmol of $Rh[(dppb)COD]BF_4$ in 10 ml of MeOH was stirred at room temperature and an initial hydrogen pressure of 51-52 bar for 89 hours. Under these conditions, 82% of the keto acid were reacted. The ratio of sodium N,N-pentamethylenealaninate to sodium lactate in the product determined by ^{1}H-NMR spectroscopy was 9.2/1.

Example 36



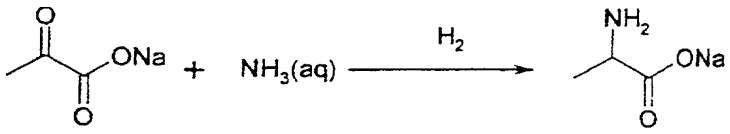
In an autoclave, a solution of 5.0 mmol of pyruvic acid, 5.0 mmol of piperidine and 0.01 mmol of Rh[(dppb)COD]BF_4 in 10 ml of MeOH was stirred at room temperature and an initial hydrogen pressure of 51-52 bar for 20 hours. Under these conditions, 99.6% of the keto acid were reacted. The ratio of N,N-pentamethylenealanine to lactic acid in the product determined by ^{1}H-NMR spectroscopy was 1.4/1.

Example 37



In an autoclave, a solution of 5.0 mmol of pyruvic acid, 5.0 mmol of benzylamine and 0.01 mmol of Rh[(dppb)COD]BF_4 in 10 ml of MeOH was stirred at room temperature and an initial hydrogen pressure of 51-52 bar for 20 hours. Under these conditions, 94% of the keto acid were reacted. N-Benzylalanine is insoluble in the reaction mixture and could be separated off by filtration. Washing with MeOH and ether gave the pure product (m.p. 238-239°C).

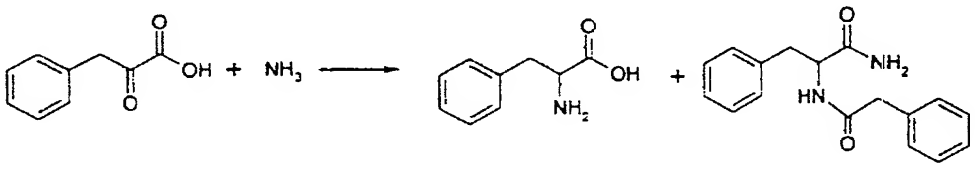
Example 38



A solution of 3.3 g (30 mmol) of sodium pyruvate in 40 ml of 25% strength ammonia solution was placed in a 100 ml autoclave fitted with a dropping funnel. The autoclave was closed, pressurized with 33 bar of hydrogen and heated to 60°C. A solution of 0.15 mmol of [Rh[(COD)Cl]$_2$ and 0.6 mmol of 2,2'-bis[[bis(3-sulfophenyl)phosphino]methyl]-4,4',7,7'-tetrasulfo-1,1'-binaphthyl octasodium salt (BINAS) in 10 ml of 25% strength aqueous ammonia solution was subsequently added from the dropping funnel and

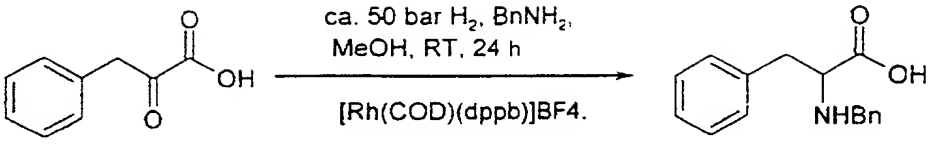
the mixture was stirred at 60°C for 16 hours. After cooling and venting the autoclave, the excess ammonia was taken off under reduced pressure, and the remaining mixture was neutralized with 10% strength hydrochloric acid until neutral to bromothymol blue, introduced onto an ion exchange column (Dowex AG 50W-X8, H form, 200-400 mesh, 25 X 2 cm), washed with 100 ml of water and eluted with 5% strength aqueous ammonia. Evaporation under reduced pressure gave 2.0 g (75%) of alanine as a colorless crystalline residue.

Example 39



A solution of 5 g (30 mmol) of phenylpyruvic acid in 50 ml of ethanol, 20 ml of 25% strength aqueous ammonia solution, 0.15 mmol of $[Rh[(COD)Cl]_2$ and 6 ml of a 0.1 molar solution of 2,2'-bis[[bis(3-sulfophenyl)phosphino]methyl]-4,4',7,7'-tetrasulfo-1,1'-binaphthyl octasodium salt (BINAS) were introduced into a 300 ml autoclave provided with an intensive magnetic stirrer and were stirred at 60°C and an initial hydrogen pressure of 42 bar. After 24 hours, the autoclave was cooled and vented. N-Phenylacetylphenylalaninamide is insoluble in the reaction mixture and could be separated off by filtration. Washing with water and alcohol gave 1.8 g (43%) of pure N-phenylacetylphenylalaninamide. The excess ammonia was removed from the mother liquor under reduced pressure. The aqueous solution was neutralized with 10% strength hydrochloric acid until neutral to bromothymol blue and rinsed onto a column of Dowex (AG 50W-X8, H form, 200-400 mesh 25 X 2 cm), washed with 100 ml of water and eluted with 5% strength aqueous ammonia. Evaporation under reduced pressure gave 0.72 g (15%) of phenylalanine as a colorless crystalline residue.

Example 40

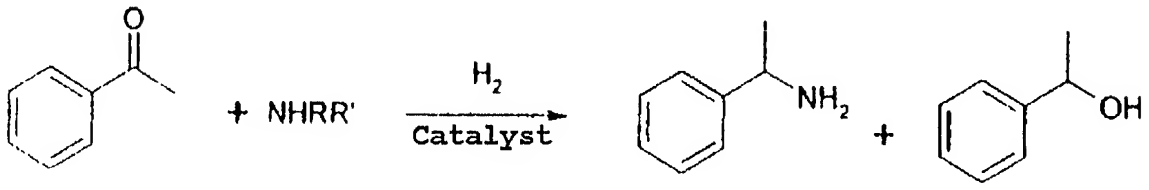


In an autoclave, a solution of 5.0 mmol of phenylpyruvic acid, 5.0 mmol of benzylamine and 0.01 mmol of Rh[(dppb)(COD)]BF_4 in 10 ml of MeOH was stirred at room temperature and an initial hydrogen pressure of 52 bar for 20 hours. Under these conditions, 99% of the keto acid were reacted. N-Benzylphenylalanine is insoluble in the reaction mixture and could be separated off by filtration. Washing with MeOH and ether gave the pure N-benzylphenylalanine (m.p. 219-220°C). Yield: 0.90 g (71%).

Examples 41 to 44

These examples were carried out in a manner analogous to Example 40. Chiral ligands and the yields and enantioselectivities are indicated in Table 5.

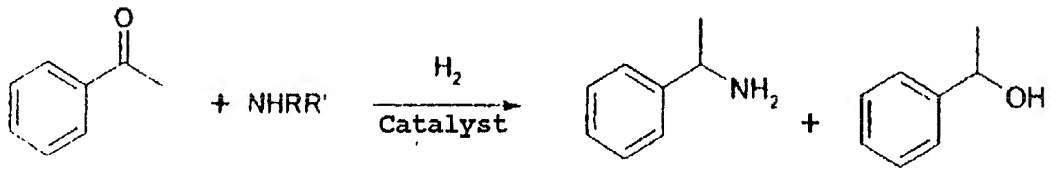
Table 1. Overview of the reductive amination of acetophenone



Example	Catalyst	Amine (acetophenone:amine)	Time (h)	Conversion of RR'C=O (%)	C-N/C-OH ratio
1[a]	Rh[(dppb)COD]BF_4[b]	$(CH_2)_5NH$ (1:1)	19.7	25.4	0.1
2[a]	Rh[(dppb)COD]BF_4[b]	$(CH_2)_5NH$ (1:1)[c]	16	5.6	2
3[a]	Rh[(dppb)COD]BF_4[b]	$BnNH_2$ (1:1)	20	10.7	0.1
4[d]	$[Ir(COD)Cl]_2$/BINAS[e] (1:4)	NH_3 (1:10)	13	38	0.22

[a]Conditions: RT, 51-52 bar (initial pressure), 5.0 mmol of acetophenone, 5.0 mmol of amine, 0.01 mmol of precatalyst, 10 ml of MeOH; [b]dppb = 1,4-bis(diphenylphosphino)butane; [c]TsOH as additive (molar ratio of additive:cat. = 20:1); [d]Conditions: 130°C, 46 bar (initial pressure), 60 mmol of acetophenone, 40 ml of 25% strength aqueous ammonia solution, 0.01 mmol of precatalyst, 40 ml of toluene; [e]BINAS = 2,2'-bis[[bis(3-sulfophenyl)phosphino]methyl]-4,4',7,7'-tetrasulfo-1,1'-binaphthyl octasodium salt.

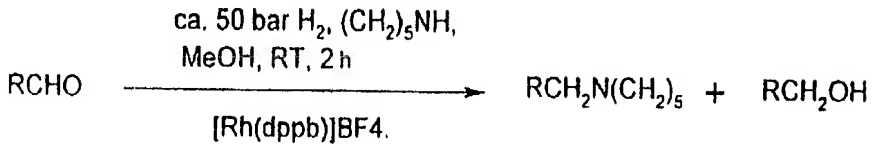
Table 2. Reductive amination of benzaldehyde



Example	Catalyst	Amine (sub./amine)	Solvent	Additive	Temp./ Pressure	Time (h)	Conversion of RR'C=O (%)	C-N(prim:sec) /C-OH
8	$Rh(PPh_3)_3Cl$	$(CH_2)_5NH$(1:1)	MeOH	-	RT/52	20	94.5	0.13
9	$[Rh(dppb)(COD)]BF_4$[b]	$(CH_2)_5NH$(1:1)	MeOH	-	RT/52	20	> 99.9	1.5
10	$[Rh(dppb)(COD)]BF_4$[b]	$(CH_2)_5NH$(1:1)	MeOH	TsOH[a]	RT/52	20	> 99 9	1.3
11	$[Rh(DPOE)(COD)]BF_4$[c]	$(CH_2)_5NH$(1:1)	MeOH	-	RT/52	20	> 99.9	1.8
12	$[Rh(DPOE)(COD)]BF_4$[c]	$(CH_2)_5NH$(1:1)	MeOH	TsOH[a]	RT/52	20	> 99.9	1 4
13	$[Rh(dppb)(COD)]BF_4$[b]	$BnNH_2$(1:1)	MeOH	-	RT/52	20	38.7	nur Amin
14	$[Rh(dcypb)(COD)]BF_4$[g]	NH_3(1:6)	MeOH	-	80/100	2	> 99	1.4 (5:6)
15	$[Rh(COD)Cl_2]_2$/TPPTS[d](1:4)	NH_3(1:7)	Hept./H_2O	-	90/46	8	> 99	4 (5:2)
16	$[Rh(COD)Cl_2]_2$/BINAS[e](1:4)	NH_3(1:7)	Tol./H_2O	$BnNMe_3Cl$[f]	100/120	3	> 99	1 (5:1)
17	$[Rh(dppb)(COD)]BF_4$[b]	NH_3(1:6)	EtOH/H_2O	-	100/79	2	> 99	0.2 (1:0)
18	$[Rh(COD)Cl_2]_2$/BINAS[e](1:4)	NH_3(1:8)	MeOH/H_2O	-	90/69	1.5	> 99	5 (12:5)

[a]Molar ratio of TsOH:cat. = 20:1; [b]dppb = 1,4-bis(diphenylphosphino)butane; [c]DPOE = 1,2-bis(diphenylphosphinoxy)ethane; [d]TPPTS = tris-(3-sulphophenyl)phosphine trisodium salt; [e]BINAS = 2,2'-bis[[bis(3-sulfophenyl)phosphino]methyl]-4,4',7,7'-tetrasulfo-1,1'-binaphthyl octasodium salt; [f]molar ratio of $BnNMe_3Cl$:cat. = 10:1; [g]dcypb = 1,4-bis(dicyclohexylphosphino)butane.

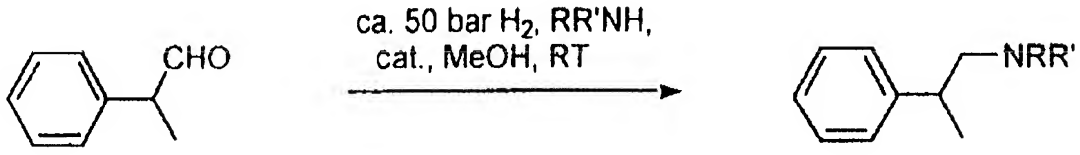
Table 3. Reductive amination of aldehydes with piperidine[a]



Example	Aldehyde	C-N/C-OH
20	4-HOC_6H_4CHO	94
21	2-MeC_6H_4CHO	50
22	4-$MeOC_6H_4CHO$	12
23	C_6H_4CHO	8:6
24	4-ClC_6H_4CHO	6.7[b]
25	4-$NO_2C_6H_4CHO$	[c]
26	PhCHMeCHO	7.5
27	EtCHMeCHO	18
28	*n*-$C_7H_{15}CHO$	210

[a]For conditions see Example 20; [b]ca. 40% of 4-$ClC_6H_4CH(OMe)_2$; [c]no reaction product, ca. 40% of 4-$NO_2C_6H_4CH(OMe)_2$

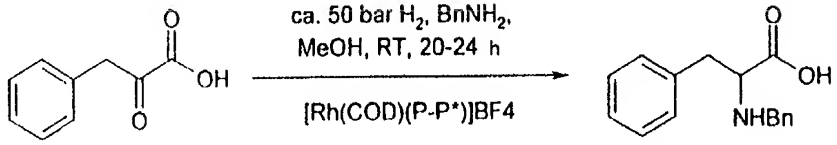
Table 4. Reductive amination of 2-phenylpropanal[a]



Example	Catalyst	Amine (amine:C=O)	Additive (ad:cat)	Conversion of RR'C=O (%)[b]	C-N/C-OH
29	$Rh(PPh_3)_3Cl$	$(CH_2)_5NH$ (1:1)	-	70.3	0.45
30	$Rh[(dppb)COD]BF_4$[c]	$(CH_2)_5NH$ (1:1)	-	> 99.9	1.8
31	$Rh[(dppb)COD]BF_4$[c]	$(CH_2)_5NH$ (2:1)	-	> 99.9	1.9
32	$Rh[(dppb)COD]BF_4$[c]	$(CH_2)_5NH$ (1:1)	TsOH (20:1)	> 99.9	4.8
33	$Rh[(DPOE)COD]BF_4$[d]	$(CH_2)_5NH$ (1:1)	-	> 99.9	6.8
34	$Rh[(DPOE)COD]BF_4$[d]	$(CH_2)_5NH$ (1:1)	TsOH (20:1)	> 99.9	3.2

[a]For conditions see Table 1; [b]Conversion after 20 h; [c]dppb = 1,4-bis(diphenylphosphino)butane;
[d]DPOE = 1,2-bis(diphenylphosphinoxy)ethane.

Table 5. Enantioselective synthesis of N-benzylphenylalanine[a]

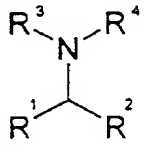


Example	Ligand (P-P*)	Yield	Ee[b]	Configuration
41		59	38	*R*
42	R-DIOP[d]	51	10	*S*
43	*R*-Bdpch[e]	58	17	*R*
44	*R*-Cyclopentyl-ppp[f]	63	12	*S*

[a]For conditions see Example 40; [b]GC analysis on the chiral column L-Chirasill-Val; [c](2*R*,3*R*,5*R*,6*R*)-2,3-dimethoxy-2,3-dimethyl-5,6-bis(diphenylphosphinomethyl)-1,4-dioxane; [d](4*R*,5*R*)-4,5-bis-(diphenylphosphinomethyl)2,2-dimethyl-1,3-dioxolane; [e](1*R*,2*R*)-1,2-bis(diphenylphosphinoxy)cyclohexane; [f](2*R*)-1-[[(diphenylphosphino)(cyclopentyl)amino]methyl]-2-diphenylphosphinoxy-3-(1-naphthalenyloxy)propane

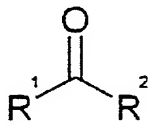
Claims

1. A process for preparing amines of the formula (III)



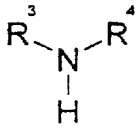
(III)

by reacting a compound of the formula (I)



(I)

with a compound of the formula (II)



(II)

where the radicals

R^1 to R^4 are selected independently from the group consisting of hydrogen, (C_1-C_{24})-alkyl, (C_2-C_{24})-alkenyl, (C_2-C_{24})-alkynyl, (C_6-C_{10})-aryl, CF_3, CN, COOH, COOM, where M is a cation selected from the group consisting of Li^+, Na^+, K^+, Mg^{2+}, Ca^{2+}, NH_4^+, $N(C_1\text{-}C_{10}\text{-alkyl})_4^+$, $N(C_1\text{-}C_{10}\text{-alkyl}/C_6\text{-}C_{10}\text{-aryl})_4^+$, CHO, SO_3H, COO-alkyl-(C_1-C_8), $CONH_2$, CONHalkyl-(C_1-C_8), $CONalkyl_2$-(C_1-C_8), CO-alkyl-(C_1-C_8), CO-phenyl, COO-phenyl, COO-aryl-(C_6-C_{10}), CO-aryl-(C_6-C_{10}), $P(aryl)_2$, $Palkyl_2$-(C_1-C_8), $PO(aryl)_2$, $POalkyl_2$-(C_1-C_4), PO_3H_2, POalkyl-(C_1-C_4)(O-alkyl-(C_1-C_6)), PO(O-

alkyl-(C_1-C_6))$_2$, SO_3-alkyl-(C_1-C_4), SO_2-alkyl-(C_1-C_6), SO-alkyl-(C_1-C_6) or Si(alkyl)$_3$-(C_1-C_8), and/or R^3 and R^4 are selected independently from the group consisting of O-alkyl-(C_1-C_8), OCO-alkyl-(C_1-C_8), O-aryl, fluorine, OH, NH_2, NH-alkyl-(C_1-C_8), N-alkyl$_2$-(C_1-C_8), NHCO-alkyl-(C_1-C_4), NHCOO-alkyl-(C_1-C_4), NHaryl-(C_6-C_{10}),
where alkyl is, for the purposes of the present invention, an unbranched or branched aliphatic or cyclic radical, where from one to four carbon atoms of the alkyl radical may be replaced by nitrogen, sulfur or oxygen atoms, alkenyl is an olefinic hydrocarbon, alkynyl is an acetylenic hydrocarbon and aryl is an aromatic radical, where from one to four carbon atoms of the aromatic radical may be replaced by nitrogen, sulfur or oxygen atoms,

alkyl, alkenyl, alkynyl and also aryl may bear substituents selected independently from among hydrogen, O-alkyl-(C_1-C_8), OCO-alkyl-(C_1-C_8), O-phenyl, phenyl, aryl(C_6-C_{10}), fluorine, chlorine, bromine, iodine, OH, NO_2, CF_3, CN, COOH, COOM, where M is a cation selected from the group consisting of Li^+, Na^+, K^+, Mg^{2+}, Ca^{2+}, NH_4^+, N(C_1-C_{10}-alkyl)$_4^+$, N(C_1-C_{10}-alkyl/C_6-C_{10}-aryl)$_4^+$, CHO, SO_3H, NH_2, NH-alkyl-(C_1-C_8), N-alkyl$_2$-(C_1-C_8), NHCO-alkyl-(C_1-C_4), COO-alkyl-(C_1-C_8), $CONH_2$, CO-alkyl-(C_1-C_8), NHCOH, NHCOO-alkyl-(C_1-C_4), CO-phenyl, COO-phenyl, COO-aryl-(C_6-C_{10}), CO-aryl-(C_6-C_{10}), CHCH-CO_2-alkyl-(C_1-C_8), P(aryl)$_2$, CHCHCO_2H, P-alkyl$_2$-(C_1-C_8), PO-aryl$_2$, POalkyl$_2$-(C_1-C_4), PO_3H_2, POalkyl-(C_1-C_4)(O-alkyl-(C_1-C_6)), PO(O-alkyl-(C_1-C_6))$_2$, SO_3-alkyl-(C_1-C_4), SO_2-alkyl-(C_1-C_6), SO-alkyl-(C_1-C_6) or Si(alkyl)$_3$-(C_1-C_8),

both R^1 and R^2 and also R^3 and R^4 can be linked by covalent bonds so that R^1 and R^2 and/or R^3 and R^4 in each case form a four- to eight-membered ring, where R^1 or R^2 may also be part of an organometallic compound,

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in the presence of hydrogen and a homogeneous catalyst system comprising at least one metal atom selected from the group consisting of Rh, Ru, Ir, Pd, Pt, Co and Ni and one or more monodentate or bidentate achiral or chiral ligands of the formula (IV) or (V)

$$(R^6Y^1)(R^7Y^1)P^1X^1ZX^2P^2(Y^2R^8)(Y^2R^9) \quad (IV)$$

$$(R^6Y^1)(R^7Y^1)(R^8Y^1)P \quad (V)$$

where

R^6 to R^9 are identical or different and are each a hydrogen atom, C_1-C_{24}-alkyl, C_2-C_{20}-alkenyl, C_3-C_8-cycloalkyl, C_5-C_8-cycloalkenyl, C_6-C_{14}-aryl, phenyl, naphthyl, fluorenyl, C_2-C_{13}-heteroaryl, where the number of heteroatoms from the group consisting of N, O, S can be 1-4,

and in which all the abovementioned substituents may each be substituted by one or more substituents selected independently from among hydrogen, C_1-C_{20}-alkyl, C_2-C_{20}-alkenyl, C_1-C_{10}-haloalkyl, C_3-C_8-cycloalkyl, C_5-C_8-cycloalkenyl, C_2-C_9-heterocycloalkyl, C_1-C_9-heterocycloalkenyl, C_6-C_{14}-aryl, phenyl, C_2-C_{13}-heteroaryl, where the number of heteroatoms from the group consisting of N, O, S can be 1-4, C_1-C_{10}-alkoxy, OCO-alkyl-(C_1-C_8), O-aryl-(C_5-C_{10}), O-phenyl, C_1-C_9-trihalomethylalkyl, fluoro, chloro, bromo, iodo, nitro, hydroxy, trifluoromethylsulfonato, oxo, thio, thiolato, amino, C_1-C_8-substituted amino of the types mono- and di-C_1-C_8-alkylamino or C_2-C_8-alkenylamino or mono-, di-, tri-C_6-C_8-arylamino or C_1-C_8-alkyl-C_6-C_8-arylamino, NH-CO-alkyl-C_1-C_8, NH-CO-aryl-C_6-C_8, cyano, C_1-C_8-acyloxy, carboxyl, carboxylato of the formula $COOR^{12}$, sulfinato, sulfonato of the formula SO_3R^{12}, phosphonato of the formula PO_3H_2, PO_3HR^{12}, $PO_3R^{12}{}_2$, where R^{12} is either a monovalent cation, NH_4^+, $N(C_1\text{-}C_{10}\text{-alkyl})_4^+$, $N(C_1\text{-}C_{10}\text{-alkyl}/C_6\text{-}C_{10}\text{-aryl})_4^+$, C_1-C_{18}-alkyl or C_6-aryl, tri-C_1-C_6-alkylsilyl,

and where two of these substituents may also be bridged,

X^1 and X^2 are each, independently of one another, a direct phosphorus-carbon bond, O, S or NR^{10}, where

R^{10} corresponds to one of the radicals defined for R^6-R^9,

Y^1 and Y^2 is a direct phosphorus-carbon bond, -O- or -NR^{11}-, where

R^{11} corresponds to one of the radicals defined for R^6-R^9,

Z corresponds to 1-6 carbon atoms which are bound to one another by single or multiple bonds and connect the unit $(R^6Y^1)(R^7Y^1)PX^1$ to the unit $X^2P(Y^2R^8)(Y^2R^9)$, where Z may be part of an aliphatic, cycloaliphatic, olefinic, cycloolefinic system which may contain from one to four heteroatoms from the group consisting of N, O, S, a metallocene, in particular a ferrocene, a 1,1'-disubstituted ferrocene, 1-(1-ethylenyl)-2-ferrocenyl or a 1,2-disubstituted ferrocene, or one or more aromatic or heteroaromatic ring systems, where the ring system comprises a total of from 2 to 14 carbon atoms which may be monosubstituted or polysubstituted by substituents as specified for R^6-R^9 or directly by C_1-C_{10}-alkoxy, OCO-alkyl-(C_1-C_8), O-aryl-(C_5-C_{10}), O-phenyl, C_1-C_9-trihalomethylalkyl, trifluoromethyl, trichloromethyl, fluoro, chloro, bromo, iodo, nitro, hydroxy, trifluoromethylsulfonato, oxo, thio, thiolato, amino, C_1-C_8-substituted amino of the formulae NH_2, NH-alkyl-C_1-C_8, NH-aryl-C_5-C_6, N-alkyl$_2$-C_1-C_8, N-aryl$_2$-C_5-C_6, N-alkyl$_3$-C_1-$C_8$$^+$, N-aryl$_2$-$C_5$-$C_6$-aryl-$C_5$-$C_6$$^+$, C_1-C_6-acyloxy, carboxylato of the formulae COOH and $COOR^{12}$, sulfinato, sulfonato of the formulae SO_3H and SO_3R^{12}, phosphonato of the formulae PO_3H_2, PO_3HR^{12} and $PO_3R^{12}{}_2$, where R^{12} is either a monovalent cation, NH_4^+, $N(C_1\text{-}C_{10}\text{-alkyl})_4^+$, $N(C_1\text{-}C_{10}\text{-alkyl/}C_6\text{-}C_{10}\text{-aryl})_4^+$, C_1-C_8-alkyl or C_6-aryl, C_1-C_6-trialkylsilyl, NHCO-alkyl-(C_1-C_4), COO-alkyl-(C_1-C_8), $CONH_2$, CON(alkyl-(C_1-C_8))$_2$, CO-alkyl-(C_1-C_8), CO-alkenyl-(C_1-C_8), NHCOO-alkyl-(C_1-C_4), CO-aryl-(C_6-C_{10}), CO-phenyl, COO-aryl-(C_6-C_{10}), COO-phenyl, CHCH-CO_2-alkyl-(C_1-C_8), $CHCHCO_2H$, and

P is a trivalent phosphorus atom.

2. The process as claimed in claim 1, wherein bidentate ligands of the formula (IV) in which R^6 to R^9 are, independently of one another, C_1-C_8-alkyl, C_5-C_6-cycloalkyl, C_6-aryl, C_4-C_5-heteroaryl, where the number of heteroatoms is 1-2, selected from the group consisting of N, O, S, and the ring size is 5-6, or are naphthyl, with these groups being able to be bear one or more substituents, preferably

substituents selected independently from among hydrogen, C_1-C_{10}-alkyl, C_1-C_6-haloalkyl, C_5-C_6-cycloalkyl, C_2-C_9-heterocycloalkyl, C_6-aryl, phenyl, C_4-C_5-heteroaryl, where the number of heteroatoms from the group consisting of N, O, S, can be 1-2, C_1-C_6-alkoxy, OCO-alkyl-(C_1-C_6), O-aryl-C_6, C_1-C_6-trihalomethylalkyl, fluoro, chloro, bromo, iodo, nitro, hydroxy, oxo, thio, thiolato, amino, C_1-C_8-substituted amino of the types mono-, di-, tri-C_1-C_8-alkylamino or C_2-C_8-alkenylamino or mono- and di-C_6-C_8-arylamino or C_1-C_8-alkyl-C_6-C_8-arylamino, NH-CO-alkyl-C_1-C_8, NH-CO-aryl-C_6-C_8, C_1-C_8-acyloxy, carboxyl, carboxylato of the formula $COOR^{12}$, sulfinato, sulfonato of the formula SO_3R^{12}, phosphonato of the formula PO_3H_2, PO_3HR^{12}, $PO_3R^{12}{}_2$, where R^{12} is either a monovalent or divalent cation (Li^+, Na^+, K^+, Mg^{2+}, Ca^{2+}), NH_4^+, $N(C_1$-C_{10}-alkyl$)_4^+$, $N(C_1$-C_{10}-alkyl/C_6-C_{10}-aryl$)_4^+$, C_1-C_8-alkyl or C_6-aryl, and tri-C_1-C_6-alkylsilyl, are used.

3. The process as claimed in either of the preceding claims, wherein R^6 to R^9 are selected independently from the group consisting of (C_3-C_8)-alkyl, (C_6-C_{10})-aryl, O-(C_5-C_8)-alkyl, O-(C_6-C_{10})-aryl or an aliphatic or aromatic (C_3-C_9)-heterocycle containing from 1 to 4 nitrogen atoms.

4. The process as claimed in any of the preceding claims, wherein R^6 and R^7 and/or R^8 and R^9 may be linked by a covalent bond so as to form a cyclic compound having from four to eight atoms.

5. The process as claimed in claim 1 or 2, wherein ligands in which Y^1 and Y^2 are each a direct phosphorus-carbon bond are used.

6. The process as claimed in any of the preceding claims, wherein Z comprises from one to four carbon atoms, in particular two carbon atoms.

7. The process as claimed in any of the preceding claims, wherein Z is a C_1-C_6-alkyl or C_2-C_6-alkenyl group or is part of a C_3-C_8-cycloalkyl, C_5-C_8-cycloalkenyl, C_2-C_9-heterocycloalkyl, C_1-C_9-heterocycloalkenyl, C_6-C_{14}-aryl, phenyl, naphthyl, fluorenyl or C_2-C_{13}-heteroaryl group, where the number of heteroatoms from the

group consisting of N, O, S can be 1-4 and all these groups may be monosubstituted or polysubstituted as described in claim 1.

8. The process as claimed in any of the preceding claims, wherein ligands in which a three- to nine-membered ring system can be formed by Z, X^1, X^2, P^1 and P^2 together with a coordinated metal are used.

9. The process as claimed in claim 1, wherein 1,4-bis(diphenylphosphino)butane, 1,4-bis(dicyclohexylphosphino)-butane, 2-diphenylphosphinomethyl-4-diphenylphosphino-1-tert-butoxycarbonylpyrrolidine, 2,3-O-isopropylidene-2,3-dihydroxy-1,4-bis(diphenylphosphino)butane, (2*R*,3*R*,5*R*,6*R*)-2,3-dimethoxy-2,3-dimethyl-5,6-bis(diphenylphosphinomethyl)-1,4-dioxane, tris-(3-sulfophenyl)phosphine trisodium salt, 2,2'-bis[[bis(3-sulfophenyl)phosphino]methyl]-4,4',7,7'-tetrasulfo-1,1'-binaphthyl octasodium salt, diphosphinite ligands based on carbohydrates, 1,2-bis(diphenylphosphinoxy)ethane, (1*R*,2*R*)-(trans)-1,2-bis-(diphenyl-phosphinoxy)cyclohexane, (2*R*)-1-[[(diphenylphosphino)(cyclo-penthyl)amino]methyl]-2-diphenylphosphinoxy-3-(1-naphthalenyl-oxy)propane and/or (4*S*)-2-(2-(diphenylphosphino)phenyl)-4-isopropyl-1,3-oxazoline are used as ligands.

10. The process as claimed in any of the preceding claims, wherein the starting materials of the formulae (I) and/or (II) used are ones whose substituents R^1 to R^4 are each, independently of one another, hydrogen, (C_1-C_{12})-alkyl, (C_2-C_{12})-alkenyl, (C_2-C_{12})-alkynyl, (C_6-C_{10})-aryl, CF_3, CN, COOH, COOM, where M is a cation selected from the group consisting of Li^+, Na^+, K^+, Mg^{2+}, Ca^{2+}, NH_4^+, $N(C_1\text{-}C_{10}\text{-alkyl})_4^+$, $N(C_1\text{-}C_{10}\text{-alkyl}/C_6\text{-}C_{10}\text{-aryl})_4^+$, COO-alkyl-($C_1$-$C_8$), $CONH_2$, CONHalkyl-(C_1-C_8), CONalkyl$_2$-(C_1-C_8), CO-alkyl-(C_1-C_8), CO-phenyl, COO-phenyl, COO-aryl-(C_6-C_{10}), CO-aryl-(C_6-C_{10}), PO(aryl-C_6-C_{10})$_2$, POalkyl$_2$-(C_1-C_4), PO_3H_2, PO(alkyl-(C_1-C_4))(Oalkyl-(C_1-C_4)), PO(O-alkyl-(C_1-C_6))$_2$ or Si(alkyl)$_3$-(C_1-C_8) and/or R^3 and R^4 are selected independently from the group consisting of O-alkyl-(C_1-C_8), OCO-alkyl-(C_1-C_8), O-aryl(C_6-C_{10}), OH, NH_2, NH-alkyl-(C_1-C_8), N-alkyl$_2$-(C_1-C_8), NHCO-alkyl-(C_1-C_4), NHCOO-alkyl-(C_1-C_4), NHaryl-(C_6-C_{10}), where alkyl is

an unbranched or branched aliphatic or cyclic or heterocyclic radical containing from one to four heteroatoms selected from the group consisting of N, O, alkenyl is an olefinic hydrocarbon, alkynyl is an acetylenic hydrocarbon and aryl is an aromatic radical which may also be an aromatic containing 1-4 heteroatoms from the group consisting of N, O and S,
and alkyl, alkenyl and alkynyl and also aryl may bear substituents selected independently from among hydrogen, O-alkyl-(C_1-C_8), OCO-alkyl-(C_1-C_8), O-phenyl, phenyl, aryl-C_6-C_{10}, fluorine, chlorine, bromine, iodine, OH, NO_2, Si-alkyl$_3$-(C_1-C_8), CF_3, CN, COOH, COOM, where M is a monovalent cation selected from the group consisting of Na, K, Rb, Cs, NH_4, N(C_1-C_{10}-alkyl)$_4$, N(C_1-C_{10}-alkyl/C_6-C_{10}-aryl)$_4$, and SO_3H, N-alkyl$_2$-(C_1-C_8), SO_2-alkyl-(C_1-C_6), SO-alkyl-(C_1-C_6), NHCO-alkyl-(C_1-C_4), COO-alkyl-(C_1-C_8), $CONH_2$, CO-alkyl-(C_1-C_8), CO-phenyl, COO-phenyl, COO-aryl-(C_6-C_{10}), CO-aryl-(C_6-C_{10}), PO-phenyl$_2$, POalkyl$_2$-(C_1-C_4), PO_3H_2, POalkyl-(C_1-C_4)(O-alkyl-(C_1-C_6)), PO(O-alkyl-(C_1-C_6))$_2$, Si(alkyl)$_3$-(C_1-C_8), where alkyl and aryl are as defined above.

11. The process as claimed in any of the preceding claims, wherein the starting materials of the formulae (I) and/or (II) used are ones in which R^1 and R^2 and/or R^3 and R^4 are linked by covalent bonds so as to form a three- to nine-membered ring.

12. The process as claimed in any of the preceding claims, wherein metal complexes having central atoms selected from the group consisting of Rh, Ru, Ir, Pd, Pt, Ni, in particular ones containing rhodium as central atom, are used as homogeneous metal atom-ligand complex.

13. The process as claimed in any of the preceding claims, wherein alkyl is an unbranched or branched aliphatic or cyclic hydrocarbon and aryl is an aromatic radical.

14. The process as claimed in claim 13, wherein both alkyl and aryl bear substituents selected independently from among hydrogen, O-alkyl-(C_1-C_8), O-phenyl, phenyl, aryl, fluorine, chlorine, OH, NO_2, Si-alkyl$_3$-(C_1-C_4), CF_3, CN, SO_3H, N-alkyl$_2$-(C_1-C_4), CO-phenyl, COO-

phenyl, COO-aryl-(C_6-C_{10}), CO-aryl-(C_6-C_{10}), PO-phenyl$_2$, PO-alkyl$_2$-(C_1-C_4), PO(O-alkyl(C_1-C_6))$_2$, Si((alkyl)$_3$-(C_1-C_8), where alkyl and aryl are as defined above.

15. The process as claimed in any of the preceding claims which is carried out at a temperature of –40-100°C.

16. The process as claimed in any of the preceding claims in which further additives are used.

17. The process as claimed in claim 16 carried out using phosphine-rhodium complexes in the presence of acids.

18. The process as claimed in any of claims 1 to 15 carried out using phosphinite-rhodium catalysts without the addition of additives.

19. The process as claimed in any of the preceding claims, wherein solvents used are alcohols, water, halogenated hydrocarbons, ethers, aromatic hydrocarbons and mixtures thereof.

20. The process as claimed in any of the preceding claims, wherein the initial hydrogen pressure is from 0.1 to 300 bar.

21. The process as claimed in any of the preceding claims, wherein the catalyst system is used in an amount of from 0.001 to 5 mol%, based on the carbonyl component of the formula (I).

Process for preparing amines by homogeneously catalyzed reductive amination of carbonyl compounds

Abstract

The invention relates to the preparation of chiral or achiral amines by reaction of aldehydes or ketones with ammonia or primary or secondary amines in the presence of hydrogen and in the presence of homogeneous metal catalysts under mild conditions. Metal catalysts which can be used are complexes of late transition metals with chiral or achiral phosphorus-containing ligands.

Declaration and Power of Attorney for Patent Application
Erklärung für Patentanmeldungen mit Vollmacht
German Language Declaration

Als nachstehend benannter Erfinder erkläre ich hiermit an Eides Statt:

daß mein Wohnsitz, meine Postanschrift und meine Staatsangehörigkeit den im nachstehenden nach meinem Namen aufgeführten Angaben entsprechen, daß ich nach bestem Wissen der ursprüngliche, erste und alleinige Erfinder (falls nachstehend nur ein Name angegeben ist) oder ein ursprünglicher, erster und Miterfinder (falls nachstehend mehrere Namen aufgeführt sind) des Gegenstandes bin, für den dieser Antrag gestellt wird und für den ein Patent für die Erfindung mit folgendem Titel beantragt wird:

Deren Beschreibung:

☐ ist beigefügt

☐ wurde angemeldet am _____

unter der US-Anmeldenummer oder unter der Internationalen Anmeldenummer im Rahmen des Vertratgs über die Zusammenarbeit auf dem Gebiet des Patentwesens (PCT)

_____ und am

_____ Abgeändert (falls zutreffend).

Ich bestätige hiermit, daß ich den Inhalt der oben angegebenen Patentanmeldung, einschließlich der Ansprüche, die eventuell durch einen oben erwähnten Zusatzantrag abgeändert wurde, durchgesehen und verstanden habe.

Ich erkenne meine Pflicht zur Offenbarung jeglicher Informationen an, die zur Prüfung der Patentfähigkeit in Einklang mit Titel 37, Code of Federal Regulations, § 1.56 von Belang sind.

As a below named inventor, I hereby declare that:

My residence, mailing address and citizenship are as stated next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled.

METHOD FOR PRODUCING AMINES BY HOMOGENEOUSLY CATALYZED REDUCTIVE AMINATION OF CARBONYL COMPOUNDS (as amended)

the specification of which

☐ is attached hereto.

☒ was filed on June 29, 2000

as United States Application Number or PCT International Application Number

PCT/EP00/06056 and was amended on

_____ (if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56.

German Language Declaration

Ich beanspruche hiermit ausländische Prioritätsvorteile gemäß Title 35, US-Code, § 119(a)-(d), bzw. § 365(b) aller unten aufgeführten Auslandsanmeldungen für Patente oder Erfinderurkunden, oder § 365(a) aller PCT internationalen Anmeldungen, welche wenigstens ein Land ausser den Vereinigten Staaten von Amerika benennen, und habe nachstehend durch ankreuzen sämtliche Auslandsanmeldungen für Patente bzw. Erfinderurkunden oder PCT internationale Anmeldungen angegeben, deren Anmeldetag dem der Anmeldung, für welche Priorität beansprucht wird, vorangeht.

I hereby claim foreign priority under Title 35, United States Code, § 119 (a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or § 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)
(Frühere ausländische Anmeldungen)

(Number) (Nummer)	(Country) (Land)	(Day/Month/Year Filed) (Tag/Monat/Jahr der Anmeldung)	Priority Claimed Priorität beansprucht Yes / Ja	 No / Nein
199 33 611.3	Germany	17 July 1999	☒	☐

Ich Beanspruche hiermit Prioritätsvorteile unter Title 35, US-Code, § 119(e) aller US-Hilfsanmeldungen wie unten aufgezählt.

I hereby claim the benefit under Title 35, United States Code, §119(e) of any United States provisional application(s) listed below.

(Application No.) (Aktenzeichen)	(Filing Date) (Anmeldetag)	(Application No.) (Aktenzeichen)	(Filing Date) (Anmeldetag)

Ich beanspruche hiermit die mir unter Title 35, US-Code, § 120 zustehenden Vorteile aller unten aufgeführten US-Patentanmeldungen bzw. § 365(c) aller PCT internationalen Anmeldungen, welche die Vereinigten Staaten von Amerika benennen, und erkenne, insofern der Gegenstand eines jeden früheren Anspruchs dieser Patentanmeldung nicht in einer US-Patentanmeldung, bzw. PCT internationalen Anmeldung in in einer gemäß dem ersten Absatz von Title 35, US-Code, § 112 vorgeschriebenen Art und Weise offenbart wurde, meine Pflicht zur Offenbarung jeglicher Informationen an, die zur Prüfung der Patentfähigkeit in Einklang mit Title 37, Code of Federal Regulations, § 1.56 von Belang sind und die im Zeitraum zwischen dem Anmeldetag der früheren Patentanmeldung und dem nationalen oder im Rahmen des Vertrags über die Zusammenarbeit auf dem Gebiet des Patentwesen (PCT) gültigen internationalen Anmeldetags bekannt geworden sind.

I hereby claim the benefit under Title 35, United States Code, § 120 of any United States application(s), or § 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application.

(Application No.) (Aktenzeichen)	(Filing Date) (Anmeldetag)	(Status: Patented, Pending, Abandoned) (Status: patentiert, schwebend, aufgegeben)
PCT/EP00/06056	June 29, 2000	
(Application No.) (Aktenzeichen)	(Filing Date) (Anmeldetag)	(Status: Patented, Pending, Abandoned) (Status: patentiert, schwebend, aufgegeben)

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POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith: (list name and registration number)

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Direct Telephone calls to: (name and telephone number)

(703) 413-3000

Vor- und Zuname des einzigen oder ersten Erfinders	Full name of sole or first inventor Thomas RIERMEIER
Unterschrift des Erfinders Datum	Inventor's signature Date Thomas Riermeier 8.2.02
Wohnsitz	Residence Moselstrasse 7, D-65439 Floersheim, Germany
Staatsangehörigkeit	Citizenship Germany DE
Postanschrift	Mailing Address same as above

Vor- und Zuname des zweiten Miterfinders (falls zutreffend)	Full name of second joint inventor, If any Karl-Josef HAACK
Unterschrift des zweiten Erfinders Datum	Second inventor's signature Date Karl-Josef Haack 20.02.02
Wohnsitz	Residence Lenzhahner Weg 5, D-65527 Niedernhausen, Germany
Staatsangehörigkeit	Citizenship Germany DE
Postanschrift	Mailing Address same as above

German Language Declaration

Vor- und Zuname des dritten Miterfinders (falls Zutreffend)	Full name of third joint inventor, If any Uwe DINGERDISSEN
Unterschrift des dritten Erfinders Datum	Third inventor's signature Date 11.2.02
Wohnsitz	Residence Linneweg 1, D-64342 Seeheim-Jugenheim, Germany
Staatsangehörigkeit	Citizenship Germany DEU
Postanschrift	Mailing Address same as above

Vor- und Zuname des vierten Miterfinders (falls Zutreffend)	Full name of fourth joint inventor, If any Armin BOERNER
Unterschrift des vierten Erfinders Datum	Fourth inventor's signature Date 15 02 02
Wohnsitz	Residence Im Winkel 40, D-18055 Rostock, Germany
Staatsangehörigkeit	Citizenship Germany DEU
Postanschrift	Mailing Address same as above

Vor- und Zuname des fünften Miterfinders (falls Zutreffend)	Full name of fifth joint inventor, If any Vitali TARAROV
Unterschrift des fünften Erfinders Datum	Fifth inventor's signature Date 15.02.02
Wohnsitz	Residence Chertanovskaya 34-1-106, Moskau, 113525, Russia
Staatsangehörigkeit	Citizenship Russian Federation RUS
Postanschrift	Mailing Address same as above

Vor- und Zuname des sechsten Miterfinders (falls Zutreffend)	Full name of sixth joint inventor, If any Renat KADYROV
Unterschrift des sechsten Erfinders Datum	Sixth inventor's signature Date Renat Kadyrov 8.02.02
Wohnsitz	Residence St. Georgstr. 40, D-18055 Rostock, Germany
Staatsangehörigkeit	Citizenship Russian Federation DEU
Postanschrift	Mailing Address same as above